Heating·Piping and Air Conditioning
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Many Problems to Solve in

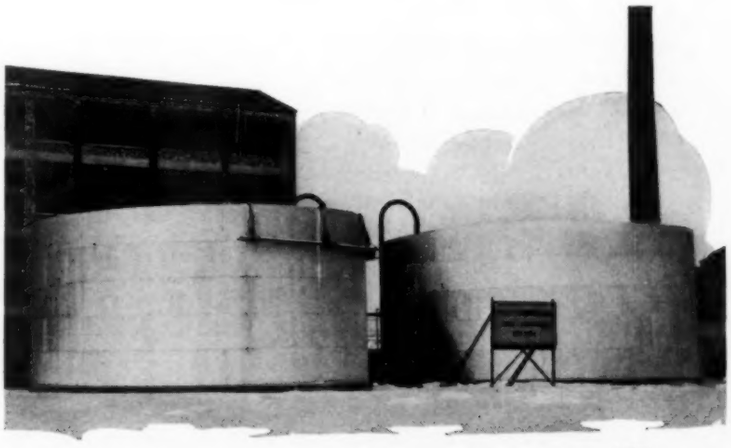
Piping and Pumping Molasses

for Industrial Process Uses

***WHEN HE SAW** the manuscript for this article, a friend of the author's who is facing the type of problem outlined here demanded a copy, said that plant engineers and others would find much-needed data herein. Recent activity of distillers has brought new problems in handling molasses, problems also met with by sugar refiners, manufacturers of stock feed, etc. Information of this kind has been scarce, grief has been experienced as a consequence. Plant engineers will find this a very practical article embodying up-to-date practice which will serve as a reliable guide for the layout of a molasses-handling system.*

THE old saying, "As slow as molasses in January," originated from the difficulties experienced in getting this sluggish, highly viscous material to flow when cold. Bad enough in early days when molasses was principally handled in barrels and jugs, the tremendous volumes which must be handled rapidly by pipe line for modern industrial processes present serious piping and pumping problems.

Molasses is made from sugar cane. After the juice is extracted by grinding and pressing the cane, it is boiled down into two commercial grades of molasses, the better quality being known as sugar stock and the residue being classified as black strap. Black strap is the heavier and more difficult grade to handle; Fig. 1 gives its viscosity at temperatures from 60 to 100 F. No accurate data about viscosity below 74 F can be obtained because of its reluctance to flow. The estimated figure for 60 F is given only to show how rapidly the viscosity increases with decrease of temperature.



Two 600,000 gallon molasses tanks at the new plant of the New England Alcohol Company at Everett, Mass. These tanks are 60 ft in diameter and 29 ft high. The picture on the cover of this issue is a close-up view of the six 24-ft diameter by 21-ft fermenters at this same plant. These tanks were supplied by the Chicago Bridge & Iron Works

By **Lee P. Hynes***

*Consulting Engineer, Philadelphia, Pa. Member of Board of Consulting and Contributing Editors.

Unloading the Molasses From Tankers

As all sugar cane is grown and converted into molasses in warm countries, no serious difficulty is experienced in handling it there. It is pumped into tank steamers which deliver it to all parts of the world. A very large amount of this raw molasses comes to the United States, Canada, and other countries where low temperatures occur during many months of the year. As the vessels can be heated, the serious handling problems do not occur until after the molasses is delivered from the ship. A typical tanker load is about 2,500,000 gallons and the

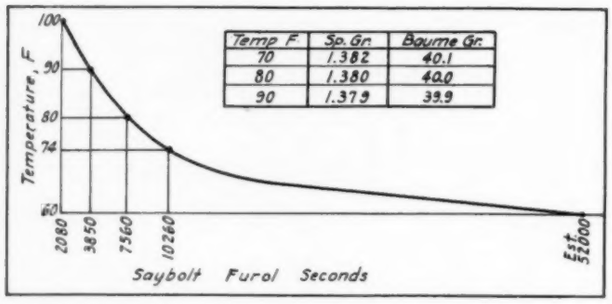


Fig. 1—Viscosity of black strap molasses, the value shown for 60 F being estimated. The chart indicates the problems met with in pumping and piping this material for industrial processes

vessel must be unloaded quickly. The real problems begin at the unloading dock, as this great volume must be transported to suitable tanks for storage until needed. The molasses in the hold of the vessel will usually be at a temperature of from 80 F to 90 F and can readily be pumped through the line to the bulk storage tanks. It is, of course, necessary to vent the tanks so that air can escape as the pumping proceeds, otherwise rupture of the tanks would result. Each of these tanks usually holds 55,000 barrels of 42 gallons each, and may be 110 ft in diameter by 32 ft high.

Fig. 2 illustrates a typical dock plan for unloading molasses. On the vessel are powerful steam-driven pumps, usually of the piston type, which pump the molasses from the hold of the vessel to a pipe line leading from the dock to suitable bulk storage tanks. A connection from the ship lines to the stationary pipe line on the dock is usually made with a 16-in. flexible metal hose having bolted flange connections at each end. From the dock a 16- or 18-in. pipe line carries the molasses 1,000 ft or more to a battery of bulk storage tanks. This pipe line terminates at the dock with a full-opening gate valve.

At the storage tanks a manifold connection with suitable valves permits delivery of molasses to any desired tank. A booster pump (not shown in Fig. 2) is often located at this manifold with bypass connections so that it can be used to help fill any tank or can pump from any tank as required.

Black strap as it comes from the ship is a very crude and dirty mixture; scraps of sugar cane, old rubber boots, bolts, nuts, mule shoes, broken parts of cane presses, or pumps, and foreign matter of all sorts may be entrained in the flow. On shipboard the large piston pumps can usually handle this matter without difficulty but the storage tank pumps are usually of the rotary type and they must be protected by suitable basket strainers.

Handling the Molasses at the Plant

Most of the black strap molasses is used by distillers of commercial alcohols and by manufacturers of stock feeds. A typical cycle of operation in a commercial distillery requires about 45,000 gallons of raw molasses per day. It is customary to have secondary storage tanks of about 50,000 gallons capacity located outdoors beside the distillery building, which may be 1,000 ft or more from the bulk storage tanks. From these secondary storage tanks the molasses is pumped as required to the process tanks in the distillery.

As the storage tanks are outdoors exposed to the elements, the stored molasses gradually loses its heat and often reaches a troublesome low temperature before it is required for use. From Fig. 1 it will be seen how this presents a difficult pumping problem. Below 80 F it will not flow freely enough for practical pumping, and must be thinned by heating. There are thus two pumping problems to be solved: (1) To pump molasses from the bulk storage tanks to the secondary storage tanks; (2) to pump it from the secondary storage tanks to the process tanks as needed. In a distillery these are at the

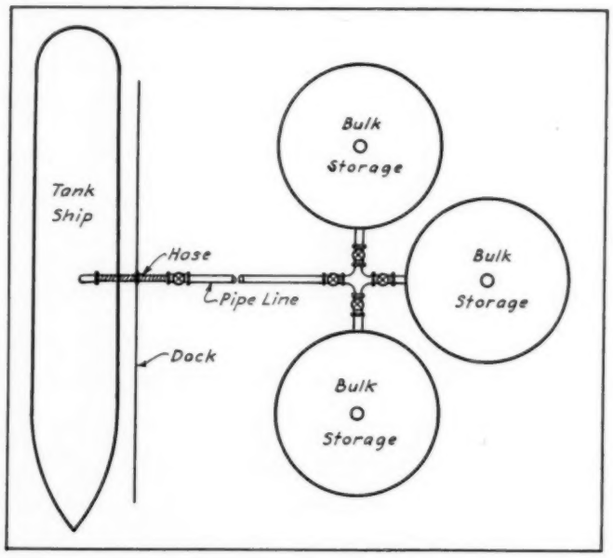


Fig. 2—Typical dock plan for unloading molasses from tanker. A booster pump (not shown) is often located at the manifold with bypass connections to help in filling or pumping from any tank

top of the building so that gravity flow can be used during manufacturing processes.

Fig. 3 shows a typical arrangement for pumping molasses from the bulk storage tank to the secondary tank. This has been simplified by not showing the manifold and bypass. Fig. 4 is a view of a typical molasses pump.

Selecting the Pump and Motor

Actual computations to determine the size of pump and motor required for a given installation must be made with a full knowledge of all the service conditions. This should only be attempted by those thoroughly experienced in this particular field of work.

For example: A job such as is diagrammed in Fig.

3, capable of delivering 400 gpm of black strap molasses of 1.379 specific gravity and a viscosity of 3,850 Saybolt Furol seconds, at 90 F, through 1,000 ft of 16-in. pipe line against a head of 65 ft, involves a theoretical working pressure for the pump of about 70 lb per sq in. This is arrived at by summing up the component factors, as follows:

Pressure due to pipe line friction.....	23	lb per sq in.
Pressure due to strainer and fittings.....	6	lb per sq in.
Pressure due to 65-ft head.....	40.5	lb per sq in.
Theoretical working pressure.....	69.5	lb per sq in.

Having determined all operating conditions, the question of pump size, speed and motor horsepower will depend on the design of pump selected. Ample overload capacity must be provided for possible changing in viscosity. This should be decided in conjunction with the pump manufacturer, who must be furnished the following definite information:

Maximum capacity required in gallons per minute.
Material to be pumped, with sample.
Viscosity at pumping temperatures.
Size of pipe line.
Maximum working pressure at desired gallons per minute.

Pumps vary in efficiency under different operating conditions but a typical installation as shown in Fig. 3 and described above would ordinarily require a 100 hp motor with suitable speed reducer to drive the pump at not more than 200 rpm. A special-purpose motor having high starting torque is necessary because of the heavy duty demanded in setting up the initial flow through the line. Compensator control with overload and undervoltage protection should be used.

Pumping Molasses to the Process Tanks

The pumping unit described will pump a day's supply of 45,000 gallons of molasses from the bulk storage tanks to the secondary storage, in about two hours' time. The

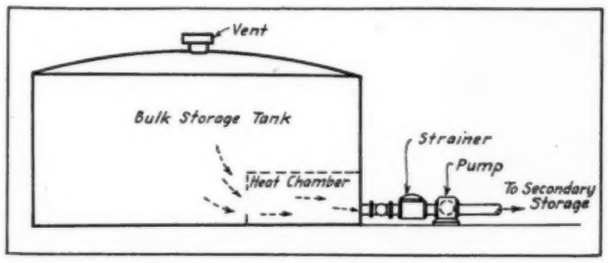


Fig. 3—Typical arrangement for pumping molasses from bulk storage tank to secondary storage. The method of heating shown here to promote easy flow is fully described in the text

process of pumping from the secondary storage to the process tanks is an intermittent one. A typical operating schedule might call for 4,500 gallons of molasses pumped in 30 minutes' time, ten such batches being required in twenty-four hours, as distillery operation is a continuous process.

Thus the pumping problem here is to handle 4,500 (45,000 ÷ 10) gallons in 30 minutes' time. Normally a 12-in. pipe line would be used. This may have 100 ft or more head in order to supply the process tanks on the top floor of the building. The pump might be driven by a 50-hp motor and the speed reduced to 180 or 200 rpm for the pump, permitting of operation up to 150 lb per sq in. pressure if required.

Pipe lines should be designed for 150 lb working pressure. The outlet of the pipe must not pour into the top of the tanks as this would mix a large amount of air with the molasses and form a troublesome, foamy mixture. It must come in at the bottom or drop down inside to the bottom. Storage tanks, pipe lines and so forth can be made of steel or iron but the pumps should preferably be bronze fitted, otherwise the working faces will be attacked by acetic acid which is present in the molasses, due to partial fermentation. Pump shafts should be of stainless steel. In laying out pipe lines it is very necessary to have a smooth inside surface without obstruction to flow. Ordinary fittings should be avoided and long smooth sweep bends utilized (see Fig. 4). Long sweep loops or expansion joints should be provided for taking care of expansion and contraction due to temperature variation.

Heating the Molasses

In order to pump molasses during cold weather it is necessary to provide some means of heating it before it enters the pump, which is difficult because molasses has the unfortunate characteristic of caramelizing at a temperature as low as 110 F. This makes it impossible to use steam coils in the storage tank or steam-jacketed pumps and intake fittings, without trouble. Attempts to use steam may result in quickly forming a solid black carbon greatly resembling the coke which forms when sugar is burned. In some cases, saturated steam has been introduced by a jet directly into the body of the molasses at the intake to the pump suction line. For distillery purposes, the introduction of water of condensation is not harmful because water is added anyway in the processing tanks. However, this introduction of steam is an unsatisfactory method of heating, because steam pockets may form and carry along into the pump, overheating particles of molasses, so as to caramelize the interior of the pump itself, and block it up with solid carbon. This frequently results in expensive shut-downs, requiring pumps to be dis-assembled and the solid carbon chipped out, a slow and expensive process.

It is possible, however, by careful design to introduce low temperature heating into the storage tank in a way which will prevent the troubles incident to the high temperature of steam. In Fig. 3 is indicated an internal chamber in the bulk storage tank sufficient in size to hold approximately one day's supply of molasses, or about 45,000 gallons. This heating chamber being internal, all heat escaping through its walls is conveyed to the surrounding body of molasses and aids in its gradual flow to the inlet of this chamber. As the inlet is 48 inches in diameter, the molasses will gradually enter, even though it is not heated to a satisfactory pumping temperature. In the heating chamber are very large areas of heating surface through which is pumped warm oil, carefully regulated so its temperature will not exceed 105 F. This circulating oil can be heated under thermostatic control in an external heater, which can be operated by steam or by electricity, whichever is most conveniently available. The pump and fittings can also be jacketed and warm oil circulated through them.

It is not necessary to heat the molasses at the rate of

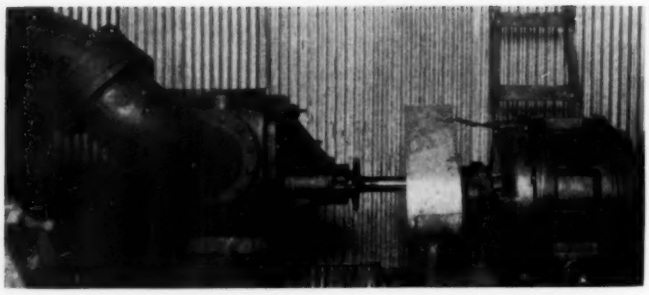


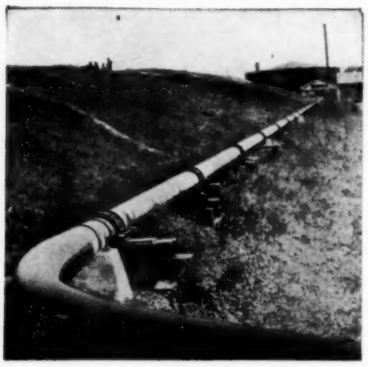
Fig. 4—Typical molasses pump, also showing the long sweep type of bend which is used

pumping. Assuming that the heating chamber holds 45,000 gallons and that this is to be pumped to the secondary storage in two hours, once every day, the heating time can be twenty-four hours. This greatly reduces the size of heating plant required and also gives time for the heat to equalize through the body of the molasses.

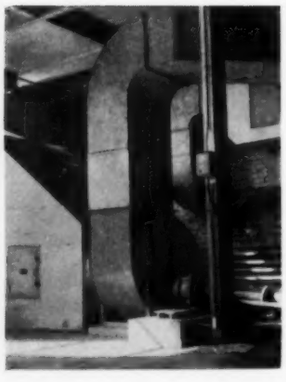
The specific heat of molasses varies somewhat according to its water content, but for safe margin should be figured at 1.0. The weight of molasses varies but will average about 12 lb per gallon—45,000 gallons would weigh about 540,000 lb and would require a maximum hourly heat input of 450,000 Btu for a temperature rise of 20 F. Average operating conditions do not require so much heat but enough must be available for the worst operating conditions likely to be encountered.

It is vital that the heating surfaces in contact with molasses be kept at a temperature not exceeding 105 F to avoid caramelization.

Fig. 5—This pipe line conveys molasses to a plant in the New Orleans district from a pier 2,000 ft distant. Located at the base of a levee, couplings are used for joining the piping system to allow for slippage of the line



Newer Methods of Brewing Beer Make Brewery Air Conditioning Essential



Air conditioning equipment in Enterprise Brewery, which employs new German method of brewing beer

WITH increased attention given modern processes of brewing beer in the United States following repeal of the prohibition amendment, air conditioning has become of greater importance to the brewery. Illustrated here is the equipment recently installed at the Enterprise Brewery, Fall River, Mass., the purpose of which is to supply cleaned air to the baudelot coolers and to the cool *pschipf*.

The cool pschipf is patterned after German practice and is said to be the first installation of its kind in America, although a number of others are in construction or about to be put in service. It consists of a room about 44 ft by 50 ft. the floor of which is a tank into which the hot wort (beer before it is fermented, aged, etc.) flows from the brew kettle. The entire room is lined with aluminum and the cooling air is forced in around the sides. The hot wort is passed through a large strainer to remove the hops quickly; the object of the cool pschipf is to effect a quick separation of the wort from the hops so that the flavor and aroma of the hops will be retained without any bitter taste due to the hops.

The air is cleaned by glass wool filters. The view of the fan and motor shows the control on the pillar: a branch duct passes through the wall in the rear of this view to convey clean air to the baudelot cooler. The other picture illustrates the main air duct supplying air to the cool pschipf directly above through the several copper ducts passing through the ceiling.—F. W.

Industrial and Comfort Air Conditioning Equipment and Application Outline

ELEMENTS OF AIR CONDITIONING and MEANS FOR ACHIEVING THEM ARE--

C O N T R O L O F

TEMPERATURE

HEAT	COOL
STEAM High pres. Low " Exhaust Vacuum HOT WATER Gravity Forced UNIT HEATER Steam Hot Water Gas Electric GRAV.Warm Air One Pipe Multi-pipe CENTRAL FAN SYSTEM	UNIT VENTILATOR Natural Draft Mechanical " CENTRAL FAN SYS. CENTRAL STATION CONDITIONER City Water Artesian Well Refrigeration DIRECT REFRIG'N UNIT COOLER Ice Mechanical EVAPORATIVE HUMIDIFIER-Preferably with air change control

HUMIDITY

REFRIGERATE	DEHUMIDIFY	HUMIDIFY
COMPRESSION SYSTEM ABSORPTION SYSTEM Gas Steam VACUUM SYSTEM Steam Jet Pump	AIR COOLED BY COILS AIR COOLED BY SPRAY AIR COOLED BY ICE CHEMICAL DEHYDRATOR	AIR WASHER HUMIDIFIER Central Fan Station with Ducts UNIT STATION FREE MOISTURE HUMIDIFIER Atomizer Centrifugal High Duty Unit Humidifier EVAPORATIVE HUMIDIFIER

MOTION

CIRCULATE	VENTILATE
NATURAL CIRCULATION FAN UNITS CENTRAL FAN SYSTEM	NATURAL VENTILATION UNIT VENTILATORS Natural Draft Mechanical " AUTOMATIC AIR CHANGER CENTRAL FAN SYSTEM

PURITY

WASH	FILTER	TREAT
HIGH DUTY HUMIDIFIER UNIT CONDITIONER CENTRAL AIR WASHER with Fan & Ducts AIR SCRUBBER	VISCOUS AIR FILTER Unit Automatic DRY AIR FILTER	IONIZE OZONATE TREAT CHEMICALLY

ANALYSIS OF TYPICAL INSTALLATIONS, SHOWING RELATIVE IMPORTANCE OF VARIOUS FEATURES

	TYPICAL INSTALLATIONS	AUTO. CONTROL OF TEMPERATURE	AUTO. CONTROL OF HUMIDITY	AUTO. CONTROL OF VENTILATION	ELIMINATION OF ODORS	CLEANNESS OF INCOMING AIR	QUIET OPERATION	* FREE MOISTURE PERMISSIBLE
FOOD INDUSTRIES	BAKERY--							
	Dough Fermentation	Important	Important	Important	Immaterial	Essential	Immaterial	Yes
	Proofing	Important	Important	Essential	Immaterial	Essential	Immaterial	Yes
	Bread Cooling	Essential	Important	Essential	Immaterial	Essential	Immaterial	Yes
	PREPARED CEREALS-- Packaging, Sealing	Important	Important	Desirable	Desirable	Essential	Immaterial	Not recommended
	CONFECTIONS--Coating, Dipping, Hard Candy Cooling, Packing, Starch Room	Important	Important	Essential	Essential	Essential	Desirable	No
	DAIRY PRODUCTS--Cheese, Butter, Butter Chill Rm.	Essential	Desirable	Helpful	Desirable	Essential	Immaterial	No
	MACARONI PRODUCTS	Essential	Important	Helpful	Immaterial	Essential	Immaterial	Not customary
TEXTILE PROCESSING	COTTON--Carding, Combing, Roving, Spinning, Twist'g, Spooling, Warping, Weaving, Cloth Room	Helpful	Essential	Important aid to humidity control and evap. cooling	Immaterial	Not often a factor	Immaterial	Yes
	WOOLEN & WORSTED-Carding, Combing, Spin'ng, Weaving	Helpful	Important	"	Immaterial	"	Immaterial	Yes
	SILK--Spin, Throw, Weave	Helpful	Essential	"	Immaterial	Desirable	Immaterial	In some cases
	RAYON--Filament Manufac.	Essential	Essential	Helpful	In some cases	Essential	Immaterial	No
	Winding, Weaving	Helpful	Essential	Helpful	Immaterial	Desirable	Immaterial	In some cases
	FULL FASHIONED HOSIERY	Essential	Essential	Helpful	Immaterial	Essential	Immaterial	Not recommended
GENERAL INDUSTRIAL	TOBACCO--Softening, Stemming, Stripping, Cigar and Cigarette Making	Important	Essential	Important	Desirable	Important	Immaterial	No
	RUBBER-Dipping Surgicals	Essential	Essential	Essential	Essential	Essential	Immaterial	No
	Spreading	Immaterial	Essential	Essential	Essential	Immaterial	Immaterial	Yes
	PRINTING AND LITHOGRAPHY	Helpful	Essential	Helpful	In some cases	In some cases	Immaterial	In some cases
	PAPER PRODUCTS	Helpful	Essential	In some cases	Immaterial	In some cases	Immaterial	In some cases
	CONDITIONING FOR REGAIN	Important	Essential	In some cases	Immaterial	In some cases	Immaterial	Not recommended
	TESTING LAB.(HYGRO.MATS)	Important	Essential	In some cases	Immaterial	In some cases	Desirable	In some cases
	STORAGE--Tobacco, Paper, Wood Products, Textiles	Important	Important	In some cases	Immaterial	In some cases	Immaterial	In some cases
	COLD STORAGE--Perishable Food Products, Furs	Essential	Important	Immaterial	Immaterial	Important	Immaterial	In some cases
NON-INDUSTRIAL	AUDITORIUMS	Desirable	Desirable	Essential	Important	Desirable	Essential	Rarely used in comfort type of air conditioner but used successfully in homes, offices, etc. to make up moisture during heating season.
	ART GALLERIES	Important	Essential	Essential	Immaterial	Essential	Essential	
	BANKS	Desirable	Desirable	Desirable	Optional	Helpful	Desirable	
	BEAUTY PARLORS	Helpful	Desirable	Desirable	Optional	Helpful	Desirable	
	BUSINESS OFFICES	Helpful	Desirable	Desirable	Optional	Helpful	Desirable	
	BROADCASTING STUDIOS	Essential	Essential	Essential	Important	Important	Essential	
	DANCE HALLS	Desirable	Desirable	Essential	Important	Desirable	Immaterial	
	DEPARTMENT STORES	Desirable	Important	Desirable	Important	Helpful	Immaterial	
	HOMES	Desirable	Desirable	Immaterial	In some cases	Helpful	Essential	
	RESTAURANTS	Important	Important	Essential	Essential	Essential	Immaterial	

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In addition to the above, building design and construction, abundance and cost of power, water and steam—all impose their limitations in the selection of air conditioning devices. Geographical locations and nature of mechanical processes in the case of industrial equipment—or occupancy in the case of non-industrial—are vital factors in determination of capacity of equipment.

*FREE MOISTURE. By this term is meant moisture delivered as a fine mist directly into the room air, by a humidifying device such as an atomizer, etc.

Oil-Fired Central Boiler Plant

MODERNIZES HEATING SYSTEM

for Five Apartment Buildings

Building No. 2 and 80-ft chimney at right of building

By **Albert E. Vroome***

MANY pages have been written and many dollars spent on the subject of increased efficiency for industrial and public utility power plants; much less has been written and but small expenditures have been made to increase the efficiency of the low-pressure heating and hot-water supply equipment which constitutes the main part of the "power plant" for apartments, schools, commercial and similar buildings. This article gives information on a low-pressure power plant and heating system for a group of apartments which was erected to increase operating efficiency and to put the apartments on a better paying basis. Briefly, the work consisted of the removal of individual heating and hot water supply equipment in 264 apartments, erection of the central boiler plant and stack, and installation of the new heating and hot water supply system. Approximately 24,400 sq ft of direct radiation were installed in 1,056 units.

The success of this modernization program furnishes a striking example of what may be accomplished in hundreds of existing buildings.

Five Apartment Buildings in Group

The Villa D'Est apartment group, near Philadelphia, consists of five buildings; the number of apartments and dimensions of each building are given in Table 1. The buildings are of fire-proof construction with flat roofs and stucco exteriors. The basements contain garages and small meter or service rooms, each apartment having a separate fire-proof garage. The apartments are on the first and second floors; each consists of a living room, bedroom, kitchenette, and bath. The original heating equipment comprised unit type gas-fired radiators with a 20-gallon gas-fired automatic water heater supplying domestic hot water for each apartment.

The apartments, built in 1926-27, were sold on the co-operative ownership plan. As business conditions grew worse from 1929 on, a large number of the owners of the apartments turned back their interest to the companies holding the first and second mortgages. Early in 1933, as business conditions reached a very low level, and over 100 of the apartments were vacant, the entire apartment group was placed in the hands of a bank and trust company to act as trustee to operate the property. The trustee collects payments from the owners who own their apartments on the co-operative plan, and rent from those who occupy apartments as tenants. It is not the intention here to go into a legal or real estate discussion; however, it is necessary to state that the entire property was owned and operated by a trustee who received money as income and paid all expenses for interest, taxes, insurance, maintenance, etc., and who held legal title to the property under the trust agreement.

It was decided that a new heating and hot-water supply system would decrease operating expenses and probably increase income by increasing the number of apartments occupied. Complete plans and specifications were prepared and proposals received in three main classes—heating and service water equipment; oil-burning equipment; and building construction for boiler house and necessary alterations to existing buildings. Contracts were awarded in September, 1933, for a total of approximately $75,000, and work started at once.

Steam was made available for the first group of apartments on December 27, 1933, and additional ones connected each day thereafter, the work being substantially completed on January 31, 1934. **The operating cost has been reduced and the apartments have had an occupancy of 95 per cent or better—as compared with 60 per cent—since the new heating plant was assured.**

Two 175-Hp Boilers Oil Fired

The boiler plant consists of two double duty fire-tube boilers set in battery, each having a manufacturer's rating of 175 hp. The boilers operate at low pressure, the average being about 10 lb gage; they are fired from the rear with motor-driven rotary type full automatic oil burners using preheated Bunker C fuel oil. There is one 10,000-gallon underground oil storage tank arranged for tank wagon oil delivery.

*Consulting Mechanical Engineer, Rutledge, Pa.

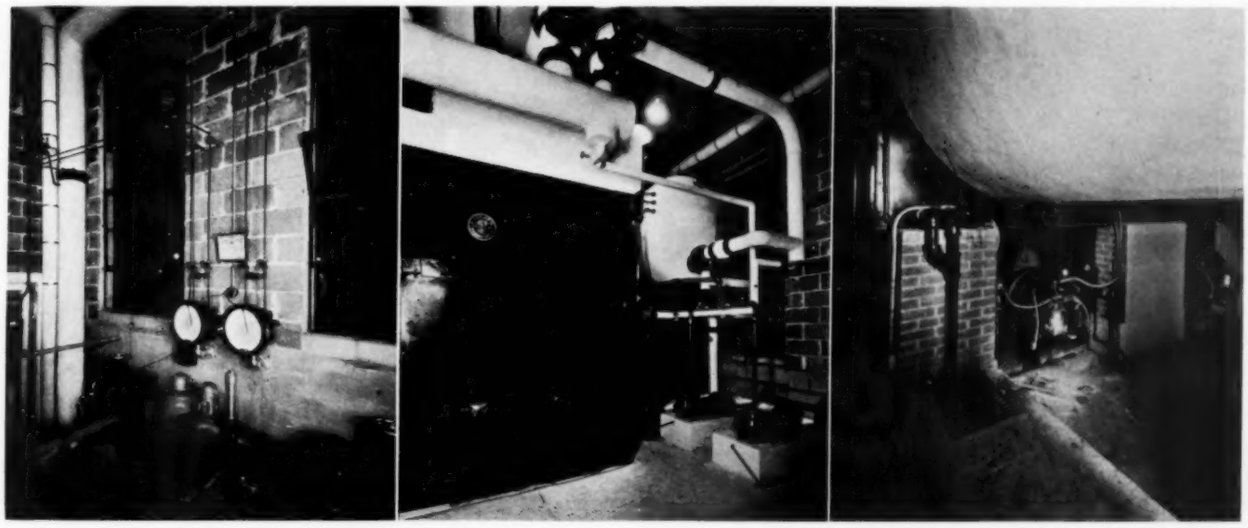
THERE ARE a number of points which the author believes all building owners, realtors, operating engineers, consulting engineers, and architects should consider after reading this article and noting the data on operation. They are:

1. A well-planned heating and hot water supply system is a big item in keeping tenants satisfied.

2. In addition to apartment buildings, there are hundreds of groups of existing houses in cities and suburban towns that could be heated and supplied with hot water from a small central plant in similar manner to that described here. On a co-operative plan the cost of heating is very little if any greater than present methods, there is no coal for the owner or tenant to shovel, ashes to take out, or oil burner to service; there is a chance to make another room in the house by renovizing the cellar.

3. When new apartment or residential groups are built, consider the advantages of the small central plant—automatic in operation, low in first cost, added space in the basements, cleanliness and, if operated properly, highly economical. If the buildings are sold, a flat charge can be made for heat and hot water, providing a suitable clause in the deed to cover charges and maintenance. If they are rented the cost of heat and hot water can be included.

4. The 264 small apartments described were only 60% occupied in February, 1933; the holders of first and second mortgages were not getting proper return on their investment; the taxes for the preceding year had not been paid; and the operating expenses were high. In February, 1934, the apartments were 95% occupied; interest payments have been made in full; taxes are all paid; operating expenses are much lower; and everybody is happy. The reason: Modernization of the heating and hot water supply system to give improved service to tenants.



Left—The two steam flow meters which aid operation of the system; the one on the left measures steam for heating, that on the right steam for water heating. The water meter below measures cold water make-up for the service water system. Center—Front of one boiler, hot water generator, and boiler-feed pumps. At the extreme right of this view is shown part of the 300-gal condensate receiver tank. Right—Oil burners at the rear of the boilers. Note that the boilers are in battery setting

(A central plant of this kind could of course be stoker- or gas-fired also, the choice of fuel depending on similar considerations to those involved in fuel selection for individual plants.)

Layout and Insulation of Piping

The steam mains leave the boiler house underground and are installed in tile conduits together with the hot water and return piping. They pass through a total of five manholes in which changes of direction are made and where expansion joints are located. Each steam main entering the building is provided with a pressure reducing valve adjusted so that the initial boiler pressure is reduced as required by the particular building. The steam mains which are run on the ceilings of the garages or in the small meter rooms are insulated with 1 in. of air cell pipe covering; the underground mains and those in the boiler house have 1 in. of 85 per cent magnesia. Return mains and risers in apartments are not insulated.

The heating system is two-pipe return with thermostatic traps at the return end of each radiator and thermostatic or float type traps for drip points in the steam mains. Each radiator is equipped with a semi-packless radiator valve and is provided with an orifice plate.

Four Pumping Units Return Condensate

The return mains in each building together with drips in the steam main are carried to a low point at the end of the building and discharged into the receiver of a vertical type condensate return pump. There are four of these pumping units having capacities ranging from 5 to 25 gpm and driven by electric motors of from ¼ to 1 hp. These pumps, operated automatically on float switch control, return the condensate to a 300-gallon

BEFORE MODERNIZATION

Apartments only 60% occupied.

Operating costs high.

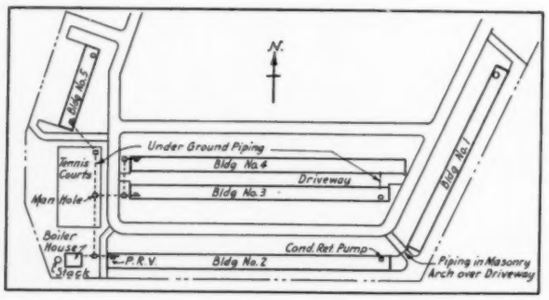
Taxes unpaid.

Mortgage holders getting no return.

condensate tank located in the boiler house. The condensate is then pumped to the boilers by motor driven centrifugal pumps operating automatically on float switch control.

Installing the Welded Piping

Since the new heating system was installed in existing occupied buildings, it was necessary to cut a total of over 4,000 holes in existing construction for the installation of mains, risers and radiator connections. The garages are approximately 8 ft wide, and where meter rooms do not occur, are 26 ft in length. The steam mains run on the garage ceiling, and every 8 ft pass through a hole cut in a garage wall. To keep the amount of welding and pipe cutting to a minimum, openings were cut in the outside building walls and the inside openings lined up, so that 20-ft lengths of pipe were



Plot plan of apartment group showing location of buildings, boiler house, the piping, and principal items of equipment

passed or threaded from one end of the building to the other, a distance of over 500 ft to the far end, and placed in position for welding. On 8-in. piping, a gang of six men did this work and on smaller piping, three and four men. The steam main together with expansion bends and the return main with its bends, were welded together before the risers or radiator connections were installed. After the steam and return mains were in place, outlets were welded into the mains and screwed piping run for riser and radiator connections.

The New Hot Water Supply System

The domestic hot water is heated by steam supplied to a copper coil located in a hot water generator having a storage capacity of 2000 gallons. The cold water make-up is taken from a 4-in. service connection from the street main. The hot water line leaving the generator runs underground in the conduit with the steam main and follows the same general run as the steam piping on the ceiling of the garages. Two of the buildings are on a loop system and the other three have a circulation line which extends back to the boiler house A 30-gpm centrifugal pump driven by a 3-hp motor circulates the hot water through the system. The average temperature of water leaving the generator is 154 F and at the pump suction, after circulation, the average is 140 F. All hot water and circulating mains are insulated with 1 in. wool-felt covering.

The hot water supply mains and recirculating mains were installed in a manner similar to that described for the steam mains except that all pipe was of screwed construction for sizes 2 in. or larger, and for sizes 1½ in. and smaller, of copper pipe with soldered streamlined bronze fittings. After the individual storage type gas-fired heaters were removed, the new hot water connections were made to the existing hot water pipe run

Table 1—Physical Data and Steam Consumption for each Building

Item	Building	No. 1	No. 2	No. 3	No. 4	No. 5
1	Number of Apartments	48	68	62	66	20
2	Length, ft	409	577	527	561	173
3	Depth, ft	27.33	27.33	27.33	27.33	27.33
4	Height, ft	25	25	25	25	25
5	Gross volume, cu ft	279,483	394,283	360,117	383,350	118,933
6	Heated volume, cu ft	175,461	247,533	226,083	242,669	74,217
7	Radiator surface, sq ft	4,473	6,276	5,734	5,989	1,925
8	Uninsulated st. risers equiv.—direct sq ft	613	867	800	851	256
9	Radiator surface C. I. total equiv. direct sq ft	5,086	7,143	6,534	6,840	2,181
10	Steam Consumption, lb, Feb. 1934, 28 days	551,000	654,000	599,000	655,000	210,000
11	Steam per 1000 cu ft gross vol. per deg day	1.65	1.39	1.39	1.43	1.48
12	Steam per 1000 cu ft heated vol. per deg day	2.63	2.21	2.22	2.27	2.38
13	Steam per 1000 sq ft C. I. radiation per deg day	103.0	87.0	87.5	92.0	91.5

Note: All steam consumption figures given in the above table have been taken from condensate meter readings. Data do not include steam losses in underground mains outside the apartments or steam for heating domestic hot water.

Table 2—Summary of Data in Table 1

1.	Total number of apartments	264
2.	Total gross cubic content, cu ft	1,536,166
3.	Total cubic content of heated space, cu ft	965,963
4.	Total sq ft direct C. I. radiation	24,397
5.	Total equiv. dir. rad. uninsulated risers, sq ft	3,387
6.	Total equiv. dir. C. I. radiator surface, sq ft	27,784
7.	Total heating steam consumption in apts., lb	2,669,000
8.	Av. steam cons. per 1000 cu ft, gross volume per degree day, lb.	1.47
9.	Av. steam cons. per 1000 cu ft heated space, per degree day, lb.	2.34
10.	Av. steam cons. per 1000 sq ft C. I. rad. surface, per deg day, lb.	92.2

Table 3—Boiler House Records

1.	Steam consumption, heating flow meter	3,002,937 lb
2.	Steam consumption, hot water flow meter	353,400 lb
3.	Total steam for heating and hot water	3,356 337 lb
4.	Gallons of domestic hot water used	296,720 gal
5.	Av. use of hot water per month per apt	1,190 gal
6.	Electricity, light and power, boiler house	3,083 kw
7.	Bunker C fuel oil, consumption	29,020 gal
8.	Gas used for burner ignition	6,000 cu ft
9.	Number of degree days, 65 F basis	1,195 deg days
10.	Time (February, 1934)	28 days
11.	Mean outside temperature	+22.2 F
12.	Highest outside temperature	+47 F
13.	Lowest outside temperature	—11 F
14.	Av. hourly wind velocity (direction N.W.)	13.5 mph

Note: *Item 1* above gives the record of all steam leaving the boiler house for apartment heating and includes the losses due to condensation in the underground steam mains. This accounts for part of the difference between *Item 1* above and *Item 7* in Table 2. About 5% of the difference between these two figures may be caused by errors in the meters.

in the floors of the apartments, the cold water connection running to the old tank being capped.

Steam Flow Meters Show Operation

Two indicating and recording steam flow meters are located in the boiler house, one to indicate and measure the total flow of steam for heating all apartments, the other to measure steam used for heating domestic hot water. At the end of the return main in each building a rotary type condensate meter is provided to measure the condensate before it enters the receiver of the vertical condensate return pump. A 4-in. water meter measures the cold water make-up for the hot water supply system. The electric meter measures all electricity used in the boiler house for power and light, and the gas meter measures the consumption of gas used in the automatic ignition of the oil burners.

Readings of the above meters are taken each day, and the data given here are based on these readings.

Operating Data for February, 1934

Tables 1, 2, and 3 are for February, 1934, the coldest month on Weather Bureau records in the vicinity of Philadelphia. The number of degree days given under *Item 9*, Table 2, is nearly 25 per cent of a normal (50-year average) Philadelphia heating season.

It should be noted that this heating layout is a plain two-pipe return system using orifice plates in the radiator valve unions for proper steam distribution, with no thermostatic temperature control. Oil burner controls maintain a boiler pressure of approximately 10 lb gage and the pressure reducing valves maintain a pressure on the reduced pressure side of from 1 to 4 lb gage depending on the length of the steam main in the building and the outside temperature.

The steam consumption per 1000 sq ft of direct radiation compares favorably with records of other apartment buildings. Steam consumption with relation to gross volume and volume of heated space is high due to the high "outside exposed surface to volume" ratio. (Note that the buildings are only 27 ft 4 in. deep and from 173 ft to 577 ft long.)

The records given are not an attempt to "sell" the idea of any special type of system or control; they were compiled by an engineer as a check on future operating results and to show steam consumption during a month of very cold weather. They are published with the hope that they will be helpful and instructive to other engineers and low-pressure plant operators.

AFTER MODERNIZATION

Apartments now 95% occupied.

Operating expenses much lower.

Taxes are all paid.

Interest payments made in full.

A Pioneer Study *on* Air Conditioning

ABOUT 30 years ago when Tyler† was engaged in pioneer work on climate and discomfort in Shanghai, little notice was taken of his work here or abroad with the result that the art missed a great deal of historical interest. A new record of this earlier work with present-day conclusions has just appeared in the *Journal of State Medicine* (British).[1]

Starting almost from scratch in 1902 about the same time as the famous British pioneer, Haldane, Tyler's first attempt was to determine a scale of discomfort in response to the high temperature and humidity conditions in Shanghai during the summer months. Twelve observers, suitably clad, sat quietly in their offices each day at noon during the month of August (1902), and recorded their sensations of discomfort according to an empirical 10-degree scale. Zero degree on the scale stood for no discomfort due to heat or moisture, and 10 stood for the worst condition experienced or imagined by the observer. The degrees of the scale were named *hyther* from "hydro" (water) and "thermos" (heat). The sensations, numbering 370 in all, were finally coordinated with dry- and wet-bulb temperatures. Air movement was not recorded but was included as a constant, and therefore it does not appear on the charts.

The accompanying figure shows one of Tyler's charts which is quite similar to Carrier's psychrometric chart with Tyler's lines of equal discomfort superimposed. The *equal* as used by Tyler does not mean equality in the physical or numerical sense—it simply applies to least observable differences of intensities or discomfort. The heavy solid lines represent actual average conditions as determined experimentally. The dotted lines represent the author's own deductions from a consideration of a "complex of guesses," as he puts it.

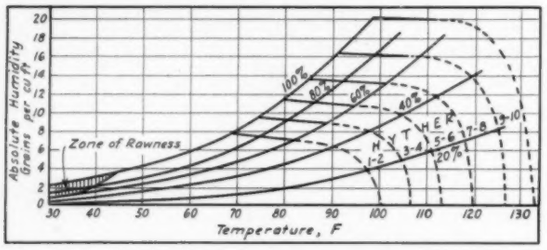
With relative humidities between 60 and 100 per cent, the degree of discomfort is shown to depend largely on the dew-point, that is the amount of moisture in the air. Dry-bulb temperature appears to have little or no effect. This does not differ greatly from Haldane's contention (1904-1907), namely, that the maximum temperature which can be borne for some hours by men performing

†At that time head of the Marine Department of the Chinese Customs Service in charge of the Service's meteorological work.

[1] "Some Psycho-Physics of Climate," by W. F. Tyler, F. R. Met. Soc., *Journal of State Medicine*, Vol 42, No. 2.

muscular work in warm atmospheres depends on the wet-bulb temperature. Bruce's contention (1916) in regard to the index of comfort is also more or less in accord with Tyler's within the specified limits of humidity (60-100 per cent).

The disagreement with subsequent and more thorough studies on comfort zones by Sheppard, Leonard Hill, Vernon, the New York Commission on Ventilation, and the *A. S. H. V. E.* research laboratory is not so serious as it would at first appear when one considers that Tyler confined his studies to conditions of discomfort due to



One of Tyler's charts, quite similar to Carrier's psychrometric chart with Tyler's lines of equal discomfort superimposed

heat under which visible or copious perspiration occurs. Wet-bulb temperature or moisture content becomes then much more important than dry-bulb temperature, as reference to an effective temperature chart will show. And for sojourns of less than 2 hours in cooled spaces (theaters, restaurants, etc.) during the heat of summer, we have but recently discovered that the best way to provide comfort and at the same time avoid chills on entering a cooled space is to keep the humidity low without much affecting the dry-bulb temperature. This is substantially in accord with Tyler's principle of more than 30 years ago. It is only within the permanent (for continuous exposures) comfort zone, or in cool atmospheres, that dry-bulb temperature becomes an important factor since the body surfaces are more or less dry, resembling the condition of a dry-bulb thermometer. We know today that high humidity in itself cannot cause discomfort unless it is accompanied by high temperatures or by temperatures under 45 F. The latter condition is often referred to as *rawness* or *damp cold*.

Besides the sensation of discomfort which apparently followed the dew-point temperature, there was (according to the author) dullness and lethargy with extreme humidity, and exhilaration, excitement, and sometimes irritation with extreme dryness. Within the author's limits, this is fairly in accord with present-day knowledge. But when we come to the general conclusion derived from the foregoing observation, it is difficult to agree with the author that the "degree of bracingness is —so far as permanent factors are concerned—a mere matter of relative humidity." The prevailing view today is that bracingness or stimulation is primarily associated with coolness or temperature drops, even when the relative humidity remains unaltered. A fall in humidity with temperature remaining constant may also be associated with similar responses, but the effect is much less conspicuous. Doubtless there are other unknown climatic factors, as the author himself points out in connection with some interesting observations of occasional strange behavior of the Chinese.

On the basis of the *hyther* index, Tyler designed and had constructed a cooling plant which operated on the principle of dehumidification by the use of ice. The air was cooled to about 50 F by passing it over ice, and then forced through the chamber to be conditioned. The sensible heat absorbed by the ventilating current in the conditioned space raised the dry-bulb temperature to that prevailing outdoors. The entire cooling effect was therefore due to the lowering of the dew point. At that time, this was the second or third plant of its kind in the world and it was installed in an operating theater of a Shanghai hospital. In spite of its apparent success, however, the opposition to the new idea was too great and the system was soon discarded. It was not until 1920 that a replica of the first system was installed in another Shanghai operating theater.

A rather serious drawback to this paper is that it is too much out of date even in what the author refers to as present-day conclusions. Tyler seems to have neglected sadly the literature on the subject, committing himself to a "complex of guesses" on matters which are now considered to be fairly well established. There is, however, a well merited justification for this; when the author was invited to give this new account of his pioneer work, he was living in retirement in France and was in entire ignorance of developments in bio-climatology, and it was only after his paper was in the press that he learned of the recent developments here and abroad. An appendix at the end of the paper gives the author's comments on the later work of others.—C. P. YAGLOU.

Use of Pipe for Piling

THOSE who are concerned with piping systems for process and industrial work seldom realize how wide a range of usefulness pipe material occupies in construction. In recent years, use of concrete-filled steel pipe in foundation work has increased rapidly, pipe piles having been driven for bridge, elevated highway, building and other foundations. In New York City alone, these requirements have called for use of about 200 miles of pipe, from 10¾ to 24 in. O.D.

This method of construction consists in driving open-end seamless or lap-welded steel tubes to bed-rock; where more than one length is necessary, two or more tubes joined by tight fitting sleeve couplings are used. After driving, material within the pipe is blown out with a jet of high pressure air, the pile is inspected, and the bottom is plugged with concrete. A second driving follows which is continued to absolute refusal, no injury resulting to steel pipe by the hard driving. The pile is then filled to the correct level with concrete, and the top is torch-cut at the elevation specified.

Rust of steel cylinders, imbedded in earth, is negligible because the ferrous oxide due to primary rusting forms a protective coating which prevents further oxidation or impairment of the steel. This statement is proved by observations taken on cylinders which had been in the ground 25 years.

Specifications for concrete-filled steel piles are to be found in the building code of the city of New York.—F. W.

New Pressure Piping Code *Reviewed*

This illustration shows new and old mains to condenser at a gas plant. The view on page 209, illustrating district heating piping, shows an anchor in a high-pressure tunnel

By **Sabin Crocker***

IN continuing our "preview" of the Proposed American Standard Code for Pressure Piping, we consider this month the sections relating to gas and air piping, and district heating piping. Next month fabrication details, expansion and flexibility will be covered.

In January, the Code requirements for power piping were discussed, computing the thickness of pipe was considered in February, and the March and April installments were devoted to the sections on oil piping for the production, transmission, and refining of petroleum. The final installment of this series is contemplated to cover the requirements for welding.

Requirements for Gas and Air Piping Systems

SECTION 2 of the Code covers piping systems for conveying air, fuel gas, and illuminating gas, these services including city gas distribution systems, cross-country transportation systems, piping in gas manufacturing plants, in gas or air-compressing stations, and in processing plants. There is a separate and distinct *A. S. A. Standard A27-1933* entitled "Recommended Practice for the Installation, Maintenance, and Use of Piping and Fittings for City Gas," which applies to the use of city gas inside the customer's premises. In addition to omitting piping for domestic use in customer's premises, Section 2 specifically excludes: (a) air piping under pressures below 30 lb per sq in.; (b) equipment or apparatus, or pipe connections which are a part of apparatus; (c) piping lined with fire-brick or other refractory material, used for conveying hot gases; (d) piping used for conveying refinery process gas in oil refineries, and ducts for waste gases and ventilation; (e) casing, tubing, and pipe used in gas or oil wells, and natural-gas field-gathering systems outside the boundaries of cities and villages.

The piping systems of Section 2 are separated into two *divisions* on account of the difference in hazard involved. *Division 1* includes gas and air piping systems within the boundaries of cities and villages, and in power, industrial, and gas-manufacturing plants wherever located. *Division 2* includes cross-country transportation systems and compressing stations, and other gas and air piping systems located outside the boundaries of cities and villages which are not included in *Division 1*.

In so far as flanges, fittings, joints, and valves are concerned a single set of requirements is given for both divisions, these being in most respects identical with the corresponding pressure requirements for Power Piping Systems reviewed in H. P. & A. C., January, 1934. The principal differences are the inclusion of *A. P. I. Specification 5L* for steel pipe, permission to use *A. P. I.* casing threads for cross-country transportation systems, and the use of *A. G. A.* standard dimensions for bell and spigot pipe.

The distinction between *Divisions 1* and *2* comes out principally in the fact that different formulas are given for the wall thickness of pipe. For *Division 1* a similar set-up is used to that described for Power Piping in the February, 1934, H. P. & A. C., with C and S values as shown in Tables 1 and 2 of that article. For *Division 2* an entirely different formula based on yield strength is used for elastic materials. This formula and the requirements governing its application are stated as follows:

"Determination of Yield Point or Yield Strength, Div. 2. The yield point or yield strength of material (except cast iron) in *Division 2*, designated as the factor Y in formulas 4 and 5, may be determined as follows:

"(a) The factor Y may be the minimum yield strength for 0.1 per cent set as determined by tension tests on specimens cut from the walls of a representative number of finished lengths of pipe in accordance with "Method of Tension Tests of Metallic Materials" *A. S. T. M. E8.*

"(b) The factor Y may be the minimum yield point for

*Engineer, The Detroit Edison Company, and Member of Board of Consulting and Contributing Editors. Among other standardization committee affiliations, Mr. Crocker is Chairman of Subcommittee 1 on Plan, Scope, and Editing of *A. S. A.* Sectional Committee *B 31* on Code for Pressure Piping.

the respective material and method of manufacture given in the specifications for such material listed in this section.

"**(c)** The factor Y may be the minimum yield strength determined by internal hydrostatic pressure tests on a representative number of finished lengths of pipe in accordance with Formula 3:

$$Y = \frac{P_y D}{2t} \quad \text{.....(3)}$$

where P_y = the pressure in lb per sq in. gage causing a volumetric set of 0.2 per cent,
t = nominal or specified pipe wall thickness in inches,
D = specified outside diameter of pipe in inches

The value of the factor Y obtained from any individual test may be rejected provided that two additional tests are made on specimens cut from the same length of pipe in the case of method specified in Par. (a) and on lengths from the same lot of pipe in the case of method given in Par. (c). In either case the lower of the two values obtained on the retests shall be used in place of the value rejected.

"**(d)** When the factor Y is determined by the method specified in Par. (a) or (b), the factor F in Formulas 4 and 5 shall be 1.4 for seamless pipe, and shall be 1.4 divided by the joint efficiency for pipe containing seams. When the factor Y is determined by method given in Par. (c), the factor F shall be 1.4 for all pipe.

Note: The term "joint efficiency" is used here to designate the ratio (not exceeding 1.0) of the yield strength as determined on a representative sample including a seam, to the yield strength as determined on a comparable sample not including a seam, except that the efficiency of mechanically constructed joints shall be calculated from the joint dimensions."

"**Hydrostatic Tests Before Erection. Div. 1.** Valves and fittings shall be capable of withstanding a hydrostatic shell test, made before erection, equal to 1.5 times the maximum working gas or air pressure except that steel valves and fittings shall be tested to pressure as given in Table 1 (shown on p. 6, H. P. & A. C., January, 1934).

Note: The term "maximum working gas or air pressure" shall be interpreted in this Section as the maximum gas or air pressure for which a given piping system may be used in conformance with the requirements of this Section of the Code.

Pipe coming under *Division 1*, shall meet the hydrostatic test requirements contained in the respective material specification listed in this Section.

"**Hydrostatic Tests Before Erection. Div. 2. (a)** Valves and fittings in piping systems within the scope of *Division 2* shall be capable of withstanding a hydrostatic test pressure of not less than 1.5 times the maximum working pressure for which the valves and fittings are rated.

"**(b)** All pipe manufactured after the adoption of this Code for use in piping systems within the scope of *Division 2* shall be subjected to and safely withstand an internal hydrostatic mill test without showing failure, leakage, distress, or distortion other than elastic distortion, at a pressure P in lb per sq in. gage, not less than provided in the appropriate specifications enumerated in this section and not greater than that calculated from Formula 4.

$$P = \frac{2.52\,Yt}{FD} \quad \text{.....(4)}$$

where Y = yield point or yield strength for respective material and method of manufacture as determined by one of the methods provided in Par. 221 at the option of the user,
t = nominal or specified pipe wall thickness in inches.
F = a factor not less than 1.4 determined according to Par. (d) above,
D = specified outside diameter of pipe in inches.

Note: When pipe is tested for which the hydrostatic mill test pressure is not stated in any of the specifications enumerated in this section, the minimum internal hydrostatic mill test pressure shall be 50 per cent of the maximum internal mill test pressure as determined according to Formula 4.

"**Working Pressure on Piping Systems in Div. 2. (a)** The maximum allowable working pressure for all piping systems within the scope of *Division 2* constructed with pipe which has been mill tested subsequent to the official adoption of this Code in accordance with Formula 4 shall be 80 per cent of the mill test pressure.

"**(b)** The maximum allowable working pressure P in lb per sq in. gage, for all piping systems within the scope of *Division 2* constructed with pipe which has not been mill tested in accordance with Formula 4 shall be determined by Formula 5.

$$P = \frac{2Yt}{FD} \quad \text{.....(5)}$$

where Y = yield point or yield strength for respective material and method of manufacture as determined by one of the methods provided above at the option of the user,
t = nominal or specified pipe wall thickness in inches,
F = a factor not less than 1.4 determined according to Par. (d) above,
D = specified outside diameter of pipe in inches.

"**(c)** The maximum allowable working pressure for cast-iron pipe coming under *Division 2* shall be based on the provisions governing cast-iron pipe for *Division 1* except that the value of S for cast iron pipe may be increased in the ratio 5/4 over the values given for *Division 1*."

District Heating Distribution Systems

SECTION 4 on District Heating covers the design, manufacture, test and installation of district heating and central heating piping systems used for the *distribution* of steam or hot water at pressures above 15 psi (lb per sq in.) gage, whether the lines are installed underground or elsewhere. This section does not apply to equipment, apparatus, or pipe connections which are a part of apparatus, nor does it apply to low pressure heating piping within buildings. Piping in heat-generating plants is classified as power piping, which is covered by Section 1 of the Code.

In general the requirements for dimensional standards, materials, pipe-wall-thickness formula, etc., are identical with those of the Section for Power Piping already reviewed in H. P. & A. C., January, 1934. Several important requirements of interest as applying particularly to district heating distribution systems are quoted below:

"**Stop Valves.** Gate valves only shall be used as stop valves in the mains. Valves may be either rising or non-rising stem."

"**Reducing and Relief Valves in Consumers' Premises. (a)** Where the street pressure exceeds 50 lb, a pressure reducing valve set at 50 lb or less shall be provided near the point of supply in consumers' premises to regulate the pressure in all building heating apparatus. A relief valve set at a safe working pressure, but not to exceed 50 lb, shall also be provided if the consumers' piping or equipment is not capable of withstanding the full street pressure, and in any case where the street pressure exceeds 50 lb, except that where two pressure reducing valves are installed in series no relief valve is required.

"**(b)** The capacity of relief valves shall be adequate to prevent more than 33⅓ per cent over-pressure with full steam flow. Relief valves shall be vented to the atmosphere.

"**(c)** The use of a hand-controlled bypass around a reducing valve is permissible. The bypass shall not be greater in capacity than the reducing valve, unless the piping is adequately protected by relief valves or is of a construction which can withstand full street pressure.

"**(d)** A pressure gage shall be installed on the low pressure side of a reducing valve. Where two reducing valves are installed in series, the pressure gage shall be installed on the low pressure side of the second reducing valve.

"**(e)** The flange dimensions, construction, and material of reducing and relief valves shall conform to the requirements of this Section for stop valves for the pressures and temperatures to which they may be subjected."

"**Drains, Drips, and Steam Traps. (a)** Drains or drips shall be provided to drain the water of condensation from the steam piping and equipment wherever it may collect. Blow-off outlets for air or condensate open to atmosphere, or connected to sewers, sumps, or receivers, shall be provided at all low points and elsewhere when necessary for the proper operation of the pipe line and equipment. Each drip, drain, and blow-off shall be controllable by at least one stop valve, located as close as practicable to the point of drainage.

"**(b)** Drip lines from steam headers, mains, separators, and other equipment shall be properly trapped with the traps installed in accessible locations. Bypasses shall be provided around steam traps unless the traps may be replaced by a spare or drainage continued by means of an open drip to the atmosphere or elsewhere at times when the trap is serviced or found inoperative.

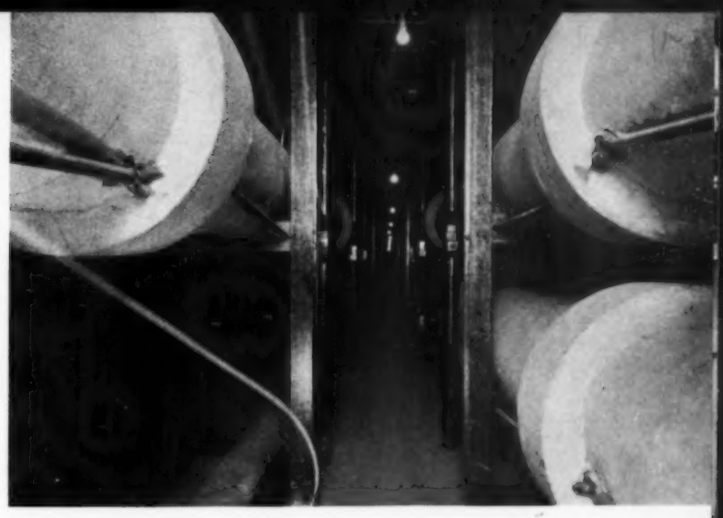
"**(c)** Drip lines from steam headers, mains, separators, or other equipment operating at different pressures, shall not be connected to discharge through the same trap. Where two or more drips operating at the same pressure discharge into the same trap, a check valve and a stop valve shall be placed in each line. Where several traps discharge into one header under pressure, or which may be under pressure, a stop valve and a check valve shall be placed in the discharge line from each trap.

"**(d)** The weight, dimensions, and materials of drip piping as far as the inlet to the trap and the trap bypass valve, if used, shall conform to the specific requirements of this Section.

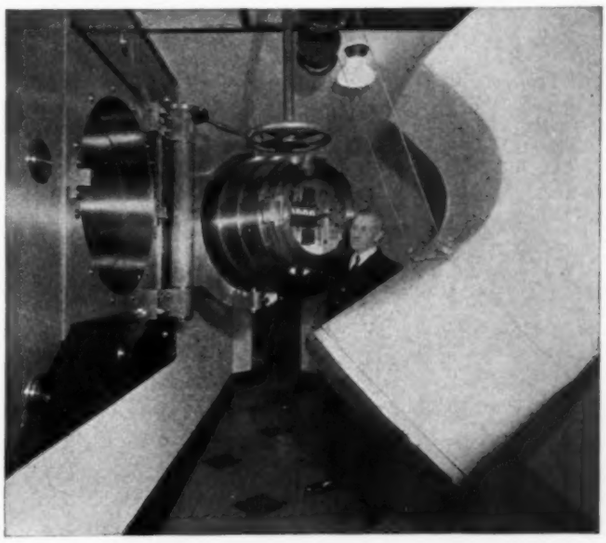
"**(e)** The weight of trap discharge piping shall be the same as the inlet piping unless the former is vented to atmosphere or operated under low pressure and has no stop valves. The trap discharge piping in all cases shall be of a weight suitable for the maximum discharge pressure to which it may be subjected. Trap discharge piping, if vented to atmosphere, shall be properly run to facilitate self discharge, and its outlet shall be so located, or proper protection provided, to prevent human injury caused by escaping steam or hot water. All trap discharge piping shall be protected against freezing, where necessary."

"**Test of Piping After Installation.** Whenever practicable, in the case of any underground piping which is to be buried or otherwise made inaccessible, the assembled lines shall first be tested hydrostatically at a pressure of 1½ times the maximum allowable service pressure and held for a period of at least two hours without evidence of leakage. Where a hydrostatic test is impracticable, the piping shall be similarly tested with steam at a pressure at least equal to the pressure at which the piping is to be operated. These tests may be made on sections, or the whole of the piping system, but the connections between the sections must be similarly tested. Welded undeground piping shall be given a hydrostatic test of 1½ times the maximum service pressure, made in accordance with the requirements of the Chapter on Welding."

Otherwise the general requirements of the Section on District Heating Systems closely resemble those for Power Piping reviewed in the January issue, with the exception of minor variations in the paragraphs on Thermal Expansion, and Hangers, Anchors and Supports. Following the general requirements for district heating piping there are several groups of specific requirements for particular service conditions embracing: (a) steam pressure above 250 and not above 400 lb and temperatures not in excess of 750 F; (b) steam pressures above 125 and not above 250 lb and temperatures not in excess of 450 F; (c) steam pressures above 25 and not above 125 lb and temperatures not in excess of 450 F; (d) steam pressures 25 lb and below and temperatures not in excess of 450 F; (e) hot water systems. The Code provides that hot water systems for pressures below 175 lb shall be designed the same as for 125 lb steam service pressure under the requirements of the 25 to 125 lb classification; for pressures from 175 to 375 lb hot water systems shall be designed the same as for 250 lb steam service.



Air Conditioned Deposit Vault Proves Popular with Tenants



The Continental Safe Deposit Company, New York City, has found its air conditioned vault to be a valuable means of attracting new tenants and holding old ones. Air conditioning expense amounts to but a few cents per tenant, the power consumption being only about twice that required for vault lighting and other electrical services. Conditioned air enters the vault duct system through the emergency door shown here which is allowed to remain open during the day. The swinging elbow at the right, when raised into position, fits the door opening and connects the duct inside the vault with that outside.

Illustration from Westinghouse Electric & Manufacturing Co.

Modernizing *with* Air Conditioning

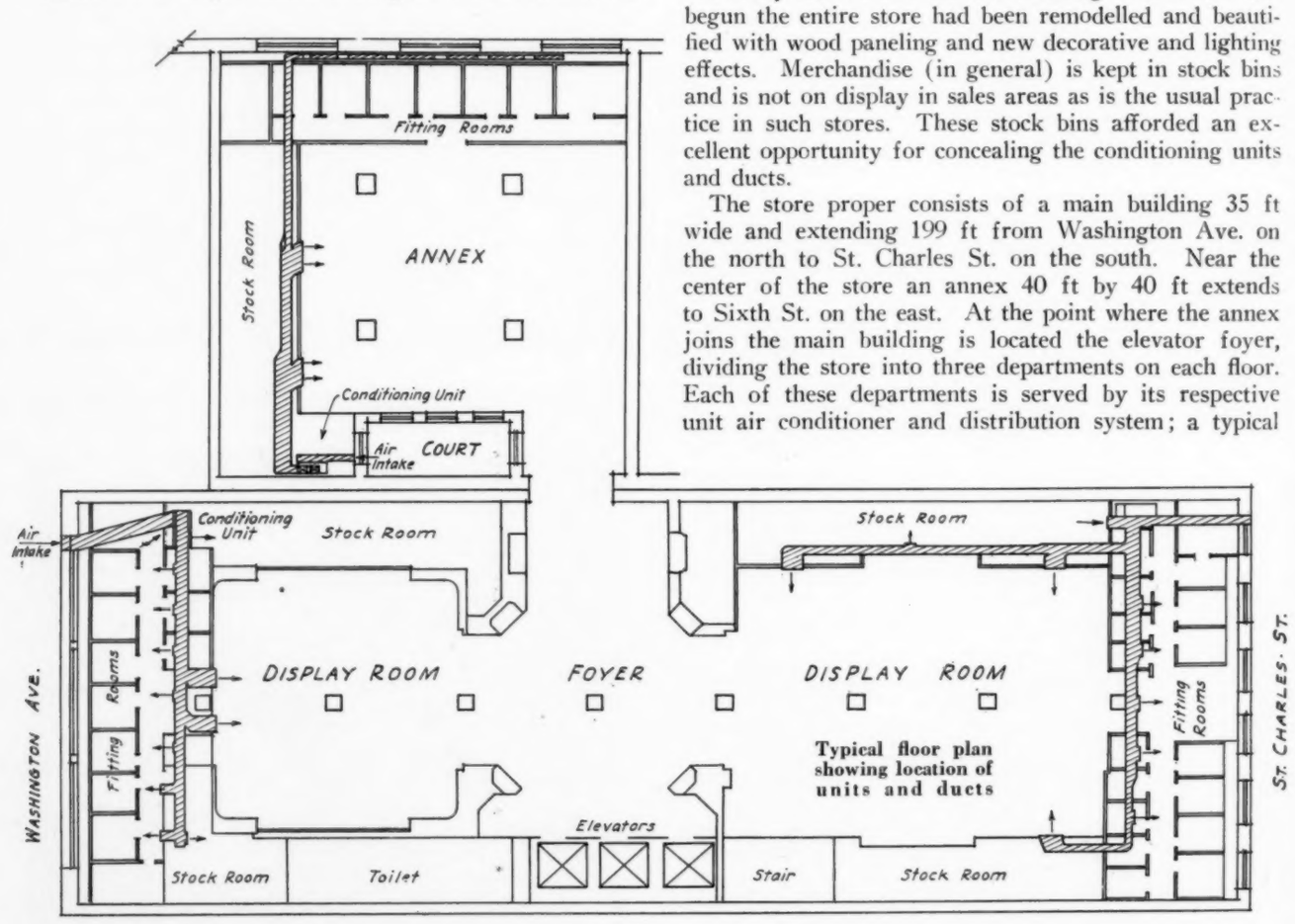
System in St. Louis Department Store Utilizes Existing Ducts and Outlets . . . No Interruption to "Business as Usual," No Sales Area Encroached Upon

LAST year, while St. Louis was sweltering in one of its hottest Junes on record, a series of advertisements in the newspapers heralded the completion of a comfort cooling installation at Kline's department store. The installation is worthy of more than passing note. It was completed in thirty working days, serves the basement and four floors of this ultra-modern department store, no part of which had to be closed for a single minute during the installation work. This was accomplished by making full use of unit air conditioners, locating them in stock bins, unused fitting rooms and over entrance doors. Every "nook and corner" of the store is supplied with cool and dehumidified air without encroaching on valuable sales area.

Units Located in Stock Bins

Shortly before this air conditioning installation was begun the entire store had been remodelled and beautified with wood paneling and new decorative and lighting effects. Merchandise (in general) is kept in stock bins and is not on display in sales areas as is the usual practice in such stores. These stock bins afforded an excellent opportunity for concealing the conditioning units and ducts.

The store proper consists of a main building 35 ft wide and extending 199 ft from Washington Ave. on the north to St. Charles St. on the south. Near the center of the store an annex 40 ft by 40 ft extends to Sixth St. on the east. At the point where the annex joins the main building is located the elevator foyer, dividing the store into three departments on each floor. Each of these departments is served by its respective unit air conditioner and distribution system; a typical



Typical floor plan showing location of units and ducts

WHERE AIR CONDITIONING is a profit-maker—as in department stores, shops, restaurants, office buildings, and other commercial structures—it is fast becoming a necessity. Today air conditioning gives a distinctly worthwhile competitive advantage to such establishments; soon, as more and more buildings are air conditioned, the extra advantages of air conditioning will become a necessity, and stores, shops, restaurants, office buildings, etc., will have to be air conditioned to "hold their own".

Therefore, more and more existing buildings will be installing air conditioning systems. It is the purpose of this article to describe how a modern conditioning system was installed in a store building without interruption to "business as usual", utilizing existing duct work and outlets insofar as was possible.

[*By* **Paul Sodemann***]

floor layout with three units and duct work is shown in the diagram.

Ammonia from Street Main Furnishes Refrigeration

At the store location, refrigeration is available in the form of liquid ammonia from a pipe line system in the street. Suitable suction line is also provided to return the ammonia gas to the central refrigeration plant several miles away. This service is utilized to cool the circulating water which is pumped through the 14 air conditioning units located in the various parts of the building.

The water is cooled to approximately 40 F, the circulating lines being covered with ice-water-thickness cork insulation. A 30-hp water circulating pump maintains a circulation of 400 gpm, receiving the water from the units and discharging it into three shell-and-tube coolers from which it again flows to the units. The rate of flow through the units is in each case controlled by a self-contained water regulating valve. A bypass is provided at the top of each set of risers to provide a flow should all of the regulating valves on that riser be closed at the same time.

Each unit air conditioner consists essentially of a set of motor-driven fans, with belt and motor, and a cooling coil through which the cold water is circulated and over which the air is moved, all enclosed in an insulated housing to prevent condensation on the outside of the unit. The cooling coil is finned copper tubing having both primary and secondary surface in contact with the air. A suitable drip pan is provided in each unit and is connected to the sewer to take care of the water condensed from the air. Before entering the unit the air passes through renewable type filters so arranged that both the outside and recirculated air is filtered. During the spring and fall months, as well as the moderate days in winter, when actual cooling is not needed a very pleasant and clean air condition can be effected in the store simply by running the fans, filtering the air, and introducing a sufficient quantity of outside air to absorb excess heat gains and provide ventilation. The constant filtration of the air alone justifies the expense of operating the fans, even though no cooling is required.

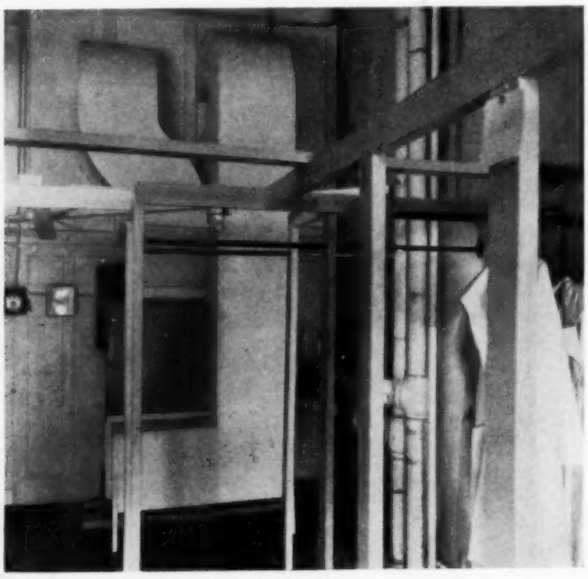
The shell-and-tube coolers, the pipe circulation lines, and the coils in the various units contain a total of 600 gallons of water which is circulated through the entire system every 1½ minutes. The circulating water is treated with an anti-freeze solution as a precaution against freezing up the coolers should the control equipment get out of adjustment. The temperature of the water leaving the coolers is automatically controlled by a thermostatic bulb, inserted in the piping leaving the coolers, which operates an electric motor valve in

*Sodemann Heat & Power Co., St. Louis, Mo.

Top to bottom—Part of first floor and balcony showing outlets located above wall cases. . . . Girls' coat shop, with grilles at one end only. . . . Coat salon on third floor. . . . View of main floor and mezzanine. . . . Boulevard dress shop, showing use of ornamental grille

the ammonia suction line. This same valve also closes immediately should the circulating pump stop for any reason.

The water leaves the cooler at about 40 F, the return temperature being governed by load conditions; the average is about 47 F, indicating an average refrigeration load of approximately 116 tons. When



starting the system on a Monday morning in hot weather the load has increased to as much as 175 tons for a short time.

Three Types of Outlets

Several methods of introducing the air into the rooms and sales areas are incorporated in the layout, as the existing duct work and registers were used wherever possible, both in the interest of economy and so as not to disturb the decorative effects. There are three separate and distinct types of outlets used on the various systems in the store. Interesting observations were possible regarding the results obtained by the various methods.

The basement had an existing duct system which was used to distribute air for heating and ventilating. The fan was disconnected and the discharge from the three fans in the cooling unit were connected into this duct system. The cooled and dehumidified air is now discharged into this duct system and delivered to the basement through the existing square lattice faces. It was found that a higher outlet velocity was desirable than had been used with the higher temperature air previously handled by this system, as the cooler air had a tendency to cascade to the floor immediately in front of and below the outlets. This was secured by blanking off the lower half of these outlets; good distribution is now had even though the trunk duct is 100 per cent greater in area than that used for the same volume of air elsewhere. In other parts of the store where practical limitations or architectural effects made it advisable to use the conventional square lattice type grilles satisfactory distribution has been secured.

The second type of grille is one of special design which had previously been installed to provide natural ventilation for the stock bins from the sales spaces. Some of these were found to be suitably located for the proper distribution of the air from the unit conditioners. They are of ornamental design having a relatively large free area, and are backed by copper screen cloth (such as is used for fly screens.) At velocities up to 650 fpm no objectionable noise has been noted and the screen cloth seems to have the effect of diffusing the cool air over the entire face. These grilles create a noticeably pleasant air motion in the area served.

The third type of outlet used is a well known slotted type which, when properly selected as regards air volume and length of blow, gives excellent and uniform distribution. The noise level is very low and when painted the same color as the wall on which it is placed, this outlet gives a very modern appearance. The application of these various outlets is shown in the illustrations.

Location of the Units

The first floor of the store has a 20-ft ceiling with a mezzanine balcony having a ceiling of about 7 ft. The unit supplying the Washington Ave. half of the first floor is located in a dressing room in the basement, the

One of the unit air conditioners located in a stock bin, showing the duct work and the cork insulated water circulating piping

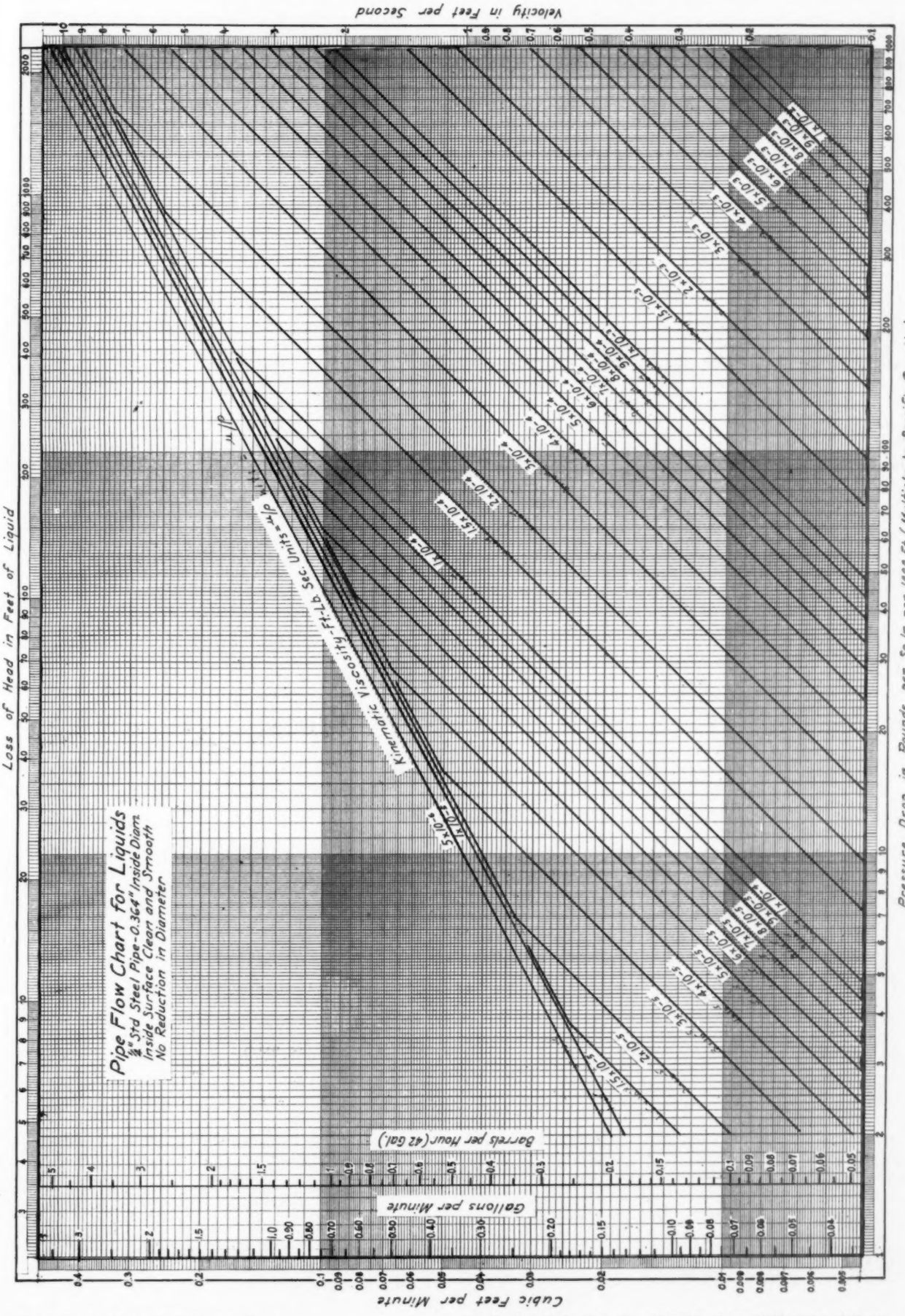
supply ducts being located on the top of show cases. The return grille to this unit is in the floor, one grille only being used for return in all cases. The unit serving the first floor portion of the store on St. Charles St. is located in an old elevator space on the mezzanine balcony and also supplies air to the main floor through a duct located on the top of the show cases, with a separate duct to three outlets on the balcony. The return air from the first floor is taken at the balcony level of the ceiling. The returning of the air to each of these units prevents the cascading of cold air down the large stairs into the basement (as might have been expected) and makes for very uniform distribution of temperature throughout. Before the cooling system was installed the balcony temperatures ranged from 5 to 15 degrees above those on the main floor level, but with the new system in operation less than 2 degrees difference exists.

Controlling the Conditioning System

Control of dry-bulb temperature is effected by controlling the rate at which the cool water is circulated through the units by means of a self-contained thermostatic regulating valve, which retards the flow when the room temperature drops below a predetermined point. The bulb of this valve is located in the return air at a point ahead of the outside air connection, thus reflecting the true room temperature. The dew-point of the air in the various rooms is controlled within limits by the temperature of the circulating water.

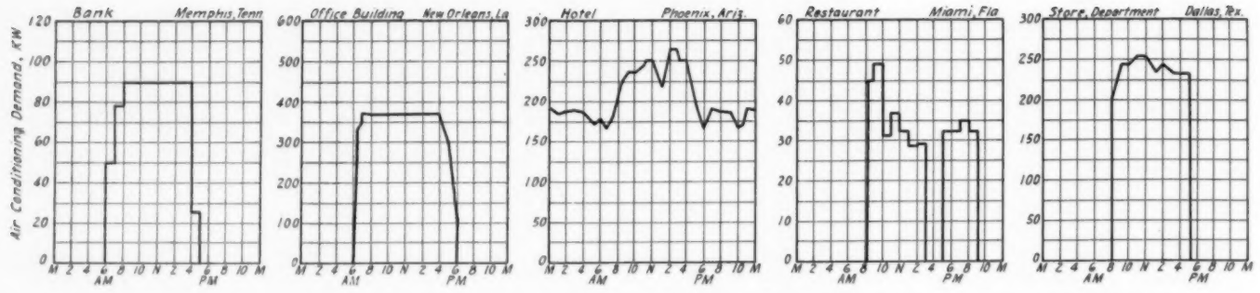
All that is necessary to start the plant is to start the motor on the water circulating pump and the motors on the various units.

Flow and Pressure Drop Calculations for Process Piping, *by* Emory Kemler*


Velocity in Feet per Second
Loss of Head in Feet of Liquid
Pressure Drop in Pounds per Sq. In. per 1000 Ft. (Multiply by Specific Gravity)
Pipe Flow Chart for Liquids
¼" Std Steel Pipe-0.364" Inside Diam
Inside Surface Clean and Smooth
No Reduction in Diameter
Kinematic Viscosity = μ/ρ Units = Viscosity-Ft-Lb Sec. Units
Barrels per Hour (42 Gal.)
Gallons per Minute
Cubic Feet per Minute

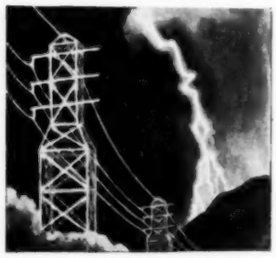
*University of Pittsburgh, Pittsburgh, Pa.

See October, 1933, issue for explanation of use of this series of charts.



Air conditioning demand, in kilowatts, for several buildings. (From Electric Bond and Share Company report on air conditioning).

The Public Utility Studies Air Conditioning



ALMOST complete picture of air conditioning as it is today and its future development—at least from the viewpoint of the public utility supplying energy in the form of electricity, gas, or steam—is given in "Air Conditioning Report to Client Companies, 1933-34," recently issued by the operating division of Electric Bond and Share Company. Consisting of 292 pages reproduced from typewritten sheets, the report represents a thorough job of discussing the sales promotion of air conditioning, analyzing electrical power rates and revenues, and describing technical developments and applications. While some may not agree with all of the views given in this report, a study of it should prove of considerable interest and value to all concerned with the development of air conditioning.

Part I of the report, devoted to sales promotion, is based on the premise that the public utilities have a large stake in the widespread application of air conditioning. Considering air conditioning as the "most modern load builder," the market in various types of buildings is outlined, manufacturers' activities and sales programs are described, a survey of client company sales promotion plans is given, and suggestions for a sales promotion program are presented.

These suggestions are presented in some detail, and in addition to pointing out what the utility company can do within its own organization, co-operation with other agencies interested in the wider application of air conditioning to industrial, commercial, and residential buildings is pointed out as a valuable sales promotion activity. Thus the utility is advised to establish a department or appoint some one individual to be responsible for promotion of air conditioning business. Accumulation of a library is advised, and attention is called to the *A.S.H. V.E. Guide*, research papers and bibliographies; the organization of a training course is also suggested.

Cooperation in Promoting Air Conditioning

As to co-operation with others, it is pointed out that the necessity for proper standards and operation of air conditioning equipment opens up a whole new field of business for many types of consulting engineers. It is pointed out that such firms can well utilize personnel in an intensive local survey to uncover prospective applications of air conditioning. A Houston consulting engineer, says the report, located 3,600 reasonably immediate prospects, while one in Nebraska found 600 in the vicinity of Omaha. Co-operation with owners of real estate needing modernization, doctors, newspapers, advertising agencies, dealers, and manufacturers is advised, as all have an interest compatible with that of the public utility.

Data on Advantages of Air Conditioning

A suggestion is made in this section of the report which might well be considered by the consulting engineer and the air conditioning contractor as well as the public utility. It is to obtain specific information on the advantages of air conditioning in all types of buildings. For instance a Memphis cafeteria reported a 300 per cent patronage increase which paid for the air conditioning installation the first season; a New Orleans department store showed an August profit the first season of operation for the first time in its history; a bakery reported faster baking and drying, the time being cut from between 12 and 24 hours to five minutes. It is pointed out that such experiences of other users in the same

Electric Bond and Share Company Issues Comprehensive Report to Client Companies

class of business are more effective in selling an air conditioning job than estimated savings and advantages. Systematic collection of such data could well be arranged for both by utilities and by others. As to electrical consumption, installation of separate test meters to measure air conditioning load characteristics where circumstances permit seems advisable and is recommended in the report.

This section of the report is concluded with a summary of client companies' air conditioning survey, based on questionnaires returned by the various companies.

Rates and Revenues

Part II covers rates and revenues for electrical power, and discusses briefly gas rates and district steam service rates for air conditioning service. Primarily of interest to utility men, it contains much for others also as a number of installations are tabulated and such information as days operated, refrigeration capacity, connected horsepower, maximum electrical demand, annual consumption, etc., is given. The tables include theaters with and without mechanical refrigeration, restaurants in hotels, separate restaurants, department stores, retail stores, hotels and apartment buildings, office buildings, individual offices, banks, and miscellaneous commercial and industrial applications. Summary tables give unit figures for connected load, maximum demand, and daily power consumption.

Rate levels and rate forms are considered in this section. The report discusses modifications of electric power rates to meet the present day seasonal variations in load occasioned by the addition of air conditioning equipment. Several charts, each relating to a typical installation, show how the kilowatt-hours for air conditioning and for the other load in buildings compare. The material in this section of the report is based upon the data supplied by client companies.

The Air Conditioning Load

As an indication of the commercial and industrial air conditioning load already served by the Electric Bond & Share client companies, the following summary is shown. This is based on approximately 150 installations which were reported, reasonably complete data being supplied for 118.

Customers represented	118
Annual air conditioning kwh	13,003,000
Total connected hp	14,950
Annual kwh per connected hp	870
Annual revenue	$213,000
Annual revenue per connected hp	$14.25
Annual revenue per kwh	1.64c

The importance of the air conditioning load is shown by the tabulation below, which gives the relation between the air conditioning load and the other loads served in establishments having air conditioning:

	Air Conditioning Load in Per Cent of Other Load		
	Maximum Demand	Annual Kwh	Annual Revenue
Theaters	137	79	60
Office buildings	159	59	47
Hotels	106	40	33
Separate restaurants	78	23	23
Banks	49	18	13
Restaurants in hotels	27	10	8

Development of Air Conditioning

Part III on technical developments and applications is both the longest and of greatest general interest. Consisting of over 200 pages, it is complete enough and so classified as to form a quite usable book on "applied air conditioning." Opening with a discussion of the trend of market and equipment designs, it considers public acceptance of air conditioning and how air conditioning in places of public assembly, in trains, at the World's Fair last year, etc., has aided in creating such acceptance. Several surveys of the present number of air conditioning installations and the future development are quoted; one, made by an established manufacturer of air conditioning equipment, indicates that the annual sales volume in the future may be expected to double itself every four years. On this assumption the figures for 1936 are annual investment, $20,000,000; connected load, kw, 260,000; annual energy consumption, million kwh, 196.5, and annual power sales, $3,930,000.

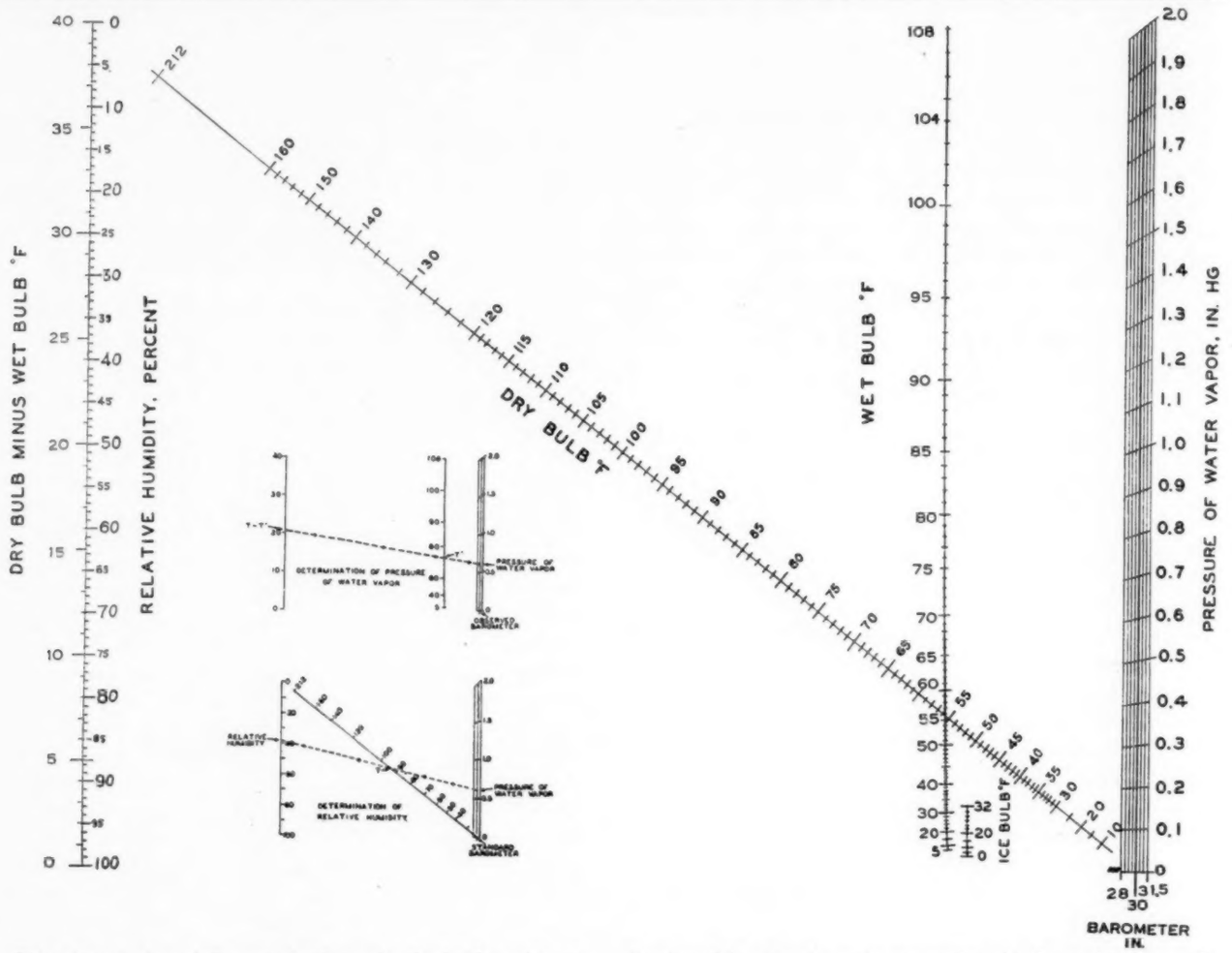
Activities of various utility groups in promoting air conditioning—such as the *Edison Electric Institute, Association of Edison Illuminating Companies, American Gas Association, National District Heating Association* and the ice industries, are briefly reviewed. Codification and certification of air conditioning installations are discussed in condensed manner.

The section then swings into detailed consideration of the engineering of air conditioning systems, covering such topics as comfort and health conditioning; technical considerations; systems and apparatus using gas, steam, and ice; and apparatus developments. Application of air conditioning in breweries and distilleries, cement testing, fur manufacture, fruit packing, hospitals, libraries and museums, studios, welding shops, etc., are discussed.

One of the most interesting parts of the report is that devoted to short descriptions of specific jobs in localities served by client companies; these include a number of stores and offices and describe the type of system installed, load requirements, operating data, etc. A number of full-page tables give detailed information on several installations which are classified according to the kind of application; this information is summarized and discussed in the text. The report concludes with several apparatus sheets, supplementing those given in the report on air conditioning equipment and practice published in November, 1932, by this company.

The present report was prepared by H. F. Smiddy representing the commercial department, L. R. Lefferson of the rate department, and Louis Elliott for the engineering department.

Psychrometric Charts for Air Conditioning* . . . *By* Donald B. Brooks


DRY BULB MINUS WET BULB °F
RELATIVE HUMIDITY, PERCENT
DRY BULB °F
WET BULB °F
ICE BULB °F
PRESSURE OF WATER VAPOR, IN. HG
BAROMETER IN.
DETERMINATION OF PRESSURE OF WATER VAPOR
DETERMINATION OF RELATIVE HUMIDITY

This chart (and a similar one based on the Centigrade scale) was developed for use in the determination of the pressure of water vapor from psychrometric observations and is based on the psychrometric formula. In the development of the two charts, it was found that the addition of two scales permitted the accurate evaluation of relative humidity as well. In comparison with the customary double interpolation tables it has been found that the use of the charts increased the precision and halved the time required.

To use the chart, place a straightedge so that it intersects the extreme left scale at the value of the difference between wet- and dry-bulb temperatures, and intersects the wet-bulb scale at the value of the wet-bulb temperature. Extend this line to the right to its intersection with the vertical line which represents the barometic pressure, and read the pressure of water vapor on the scale at the extreme right. This value includes all necessary corrections.

Example: Suppose a psychrometer reads 75 F on the dry bulb and 65 F on the wet bulb when the barometer is 30.5 in. Hg. To find the pressure of water vapor, place a ruler so that it intersects the "dry-bulb minus wet-bulb, F" scale at 75-65 = 10. Adjust so that the ruler meets the "wet-bulb, F" scale at 65, and note the point at which it intersects the 30.5 in. barometer line (first line right of heavy vertical line marked 30); the value of the pressure of water vapor so obtained is 0.51 in Hg. A computation from the psychrometric formula gives 0.5083 in Hg.

To determine the relative humidity, transfer the value of the pressure of water vapor obtained as described to the corresponding point on the central heavy vertical line representing standard barometric pressure (30 in.). Connect by straightedge this point and the point representing the dry-bulb temperature on the diagonal line marked "Dry Bulb." Extend the line to its intersection with the vertical line on the left, and read relative humidity on the inner left scale.

Example: Continuing the example started above, locate the point on the heavy vertical 30 in. barometer line which represents 0.51 in. Hg. pressure of water vapor, and connect this point by ruler with the point at 75 F on the diagonal line marked "dry-bulb, F". By extending the line located by the ruler to its intersection with the vertical line at the left, the value 57.8 per cent relative humidity is obtained, reading the "relative humidity, per cent" scale on the inner side of the left vertical line. Note that this scale reads from 0 at the *top* to 100 at the *bottom*. By computations, the relative humidity for the example selected is found to be 58.03 per cent.

In obtaining the pressure of water vapor when the wet-bulb temperature is below freezing, the scale marked "Wet Bulb" is employed if the psychrometer was used with either supercooled water or a frozen wick. However, more accurate results can be obtained with an ice-coated thermometer, and the 'Ice Bulb" scale (to the right of the "Wet Bulb" scale) is used in place of the "Wet Bulb" scale.

This Fahrenheit chart is based on Professor Ferrel's psychrometric formula, which is used in the United States Weather Bureau's Psychrometric Tables.[1] This formula is

$$e = e' - 0.000367P\ (t - t')\ \left(1 + \frac{t' - 32}{1571}\right)$$

in which t and t' are the temperatures of the dry- and wet-bulb thermometers, in degrees Fahrenheit; P is the barometric pressure at the psychrometer, in inches of mercury; e' is the saturation pressure of water vapor in inches of mercury at the temperature t' of the wet bulb; and e is the atmospheric humidity in inches of mercury.

The Centigrade chart (not shown here) is based on the analogous formula

$$e = e' - 0.000652P\ (t - t')\ (1 + 0.00102t')$$

in which P, e', and e are expressed in millimeters of mercury, and t and t' in degrees Centigrade. The constants used in this formula are based on recent data,[2,3] which are believed to be more accurate, rather than on the values corresponding to those used by the United States Weather Bureau, and employed in constructing the Fahrenheit chart, which would be 0.000660 and 0.00115, respectively. The two charts do not agree exactly; however, the difference will obviously be of the order of the experimental error.

*Reprinted by permission from *Bureau of Standards Miscellaneous Publication* No. 143, which is available from the Superintendent of Documents, Washington, D. C., for 5c.

[1] *Psychrometric Tables, W. B.* No. 235.

[2] *Feuchtigkeitsmessung*, by Dr. Herman Bongards.

[3] *Journal of the Washington Academy of Sciences*, March 15, 1933.

Heating·Piping
and Air Conditioning

American Society of Heating and Ventilating Engineers JOURNAL SECTION

MAY 1934

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Study of Fuel Burning Rates and Power Requirements of Oil Burners in Relation to Excess Air

By **L. E. Seeley**[1] **and E. J. Tavanlar,**[2] **New Haven, Conn.**

(MEMBERS)

This paper is the result of research conducted at Yale University, New Haven, Conn., in cooperation with the A. S. H. V. E. Research Laboratory and the American Oil Burner Association.

PREVIOUS studies on oil burners and heating boilers have revealed performance characteristics such as: boiler efficiencies at different outputs; the effects of furnace drafts, intermittent operation, excess air on output and efficiency, comparisons of oil and gas, measurements of sound, etc. Much of the above was necessarily determined according to certain fixed operating standards in order that the comparisons might be entirely valid. None of the work has adequately revealed, however, the complete operating range of an oil burner as it relates to maximum and minimum oil-burning rates with varying proportions of excess air.

Previous standard tests, called Series A tests, have always revealed well-defined maximum and minimum fuel-burning rates. Testing standards called invariably for clean combustion at 10 per cent CO_2 (or 50 per cent excess air) and a furnace draft of 0.02 in. of water. It seemed evident that, depending upon the operating conditions selected, the maximum and minimum fuel-burning rates would continue to be equally well defined though probably of a different order. It was thought worth while to investigate this phase of burner operation completely since it would provide a more comprehensive picture relative to oil burner capacities and it might also reveal certain limiting factors which might or might not be inherent in the burner itself.

It was also felt that such an investigation would raise some questions in regard to capacity listings of oil burners without qualification as to operating conditions and it should also suggest desirable standards in the event of adopting qualifying standards of operation.

The upper limit in fuel-burning rate might be determined by: (1) oil supply; (2) air supply; (3) furnace size and/or furnace design or; (4) undesirable combustion vibrations or sounds. These factors inhere in the device itself or in its installation. Additional limiting factors might be due to the boiler, such as: (5) small furnace or firepot volume; (6) excessive draft loss due to small flue passages and/or long flue gas travel. These factors are extraneous to the burner itself as would also be the limitation induced by a chimney of insufficient capacity. These latter factors are too uncertain and variable to consider at this time although their possibilities should be recognized.

The lower limit in fuel-burning rate may be determined by such factors as: (1) degree of fuel atomization; (2) effectiveness of mixing oil and air, and (3) furnace size and/or design. It is assumed that conditions necessary for satisfactory ignition are present. While an evaluation of these factors is somewhat more speculative, it is believed that actual tests may show some interesting characteristics according to types of oil burners.

An example of capacity tests is shown by Fig. 1. Curve A_2 shows the fuel-burning rates possible with the maximum supply of air available at various percentages of excess air. The air supply in this case was provided entirely by a fan; the air adjustment was kept wide open and the furnace draft was maintained at 0.02 in. of water. The decrease in fuel-burning rate is very marked between 50 and 250 per cent of excess air and less marked above 250 per cent.

Curve B_2 represents the least quantity of oil that could be burned at various proportions of excess air. In this case the air supply was reduced to its minimum value by means of an air adjustment provided on the burner. This leaves some uncertainty as to whether or not the fuel rate could have been further reduced by a more positive air adjusting device. A furnace draft of 0.02 in. of water was maintained in these tests.

Curve A_7 was similar to A_2 except that the furnace draft was raised to 0.07 in. of water. It should be pointed out in connection with comparisons of Curves A_2 and A_7 that every flue gas analysis has some degree of error due to air leakage into the boiler. While air leakage is kept as low as possible, because of this fact, it is necessary, for really comparative tests, to keep this air leakage constant. This is done by maintaining the same furnace draft for each series of tests. A comparison of two series of tests at different furnace drafts involves some unknown change in the air leakage rate. The exact curves therefore would probably be closer together than those shown here.

The range in fuel burning rates at 50 per cent of excess air appears to run from 8.4 to 32.8 per hour. The greatest overall range exists at the lowest percentage of

[1] Assistant Professor of Mechanical Engineering, School of Engineering, Yale University.

[2] Graduate student, Graduate School, Yale University.

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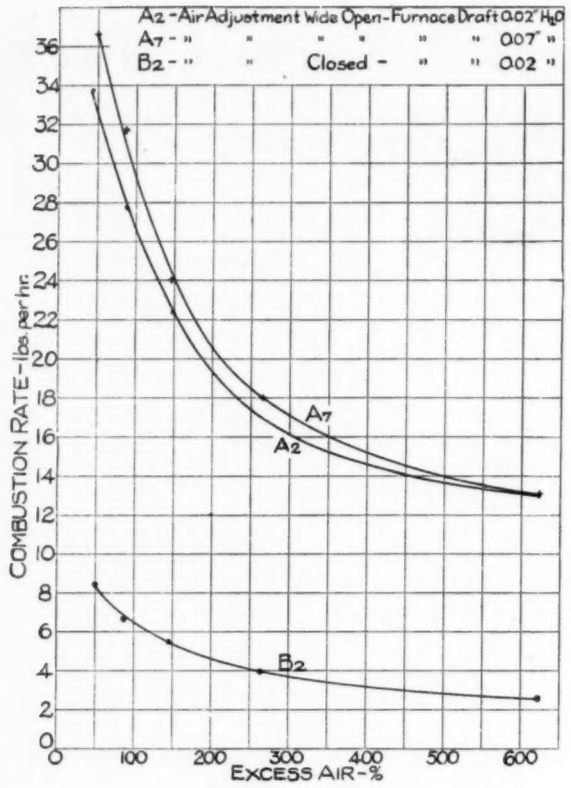


Fig. 1—Fuel-burning rates v. per cent excess air

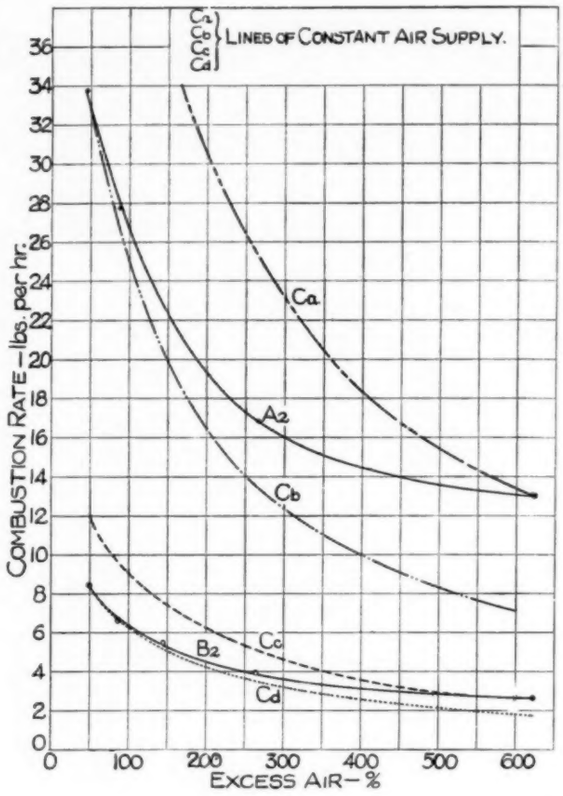


Fig. 3—Fuel-burning rates v. per cent excess air, and lines of constant air supply

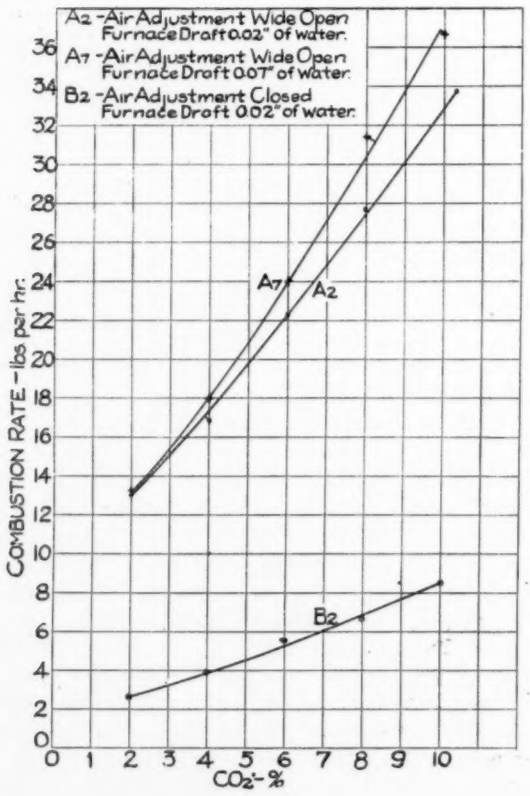

A2 - Air Adjustment Wide Open Furnace Draft 0.02" of water.
A7 - Air Adjustment Wide Open Furnace Draft 0.07" of water.
B2 - Air Adjustment Closed Furnace Draft 0.02" of water.
COMBUSTION RATE - lbs. per hr.
CO2 - %
A7
A2
B2

Fig. 2—Fuel-burning rates v. per cent CO_2

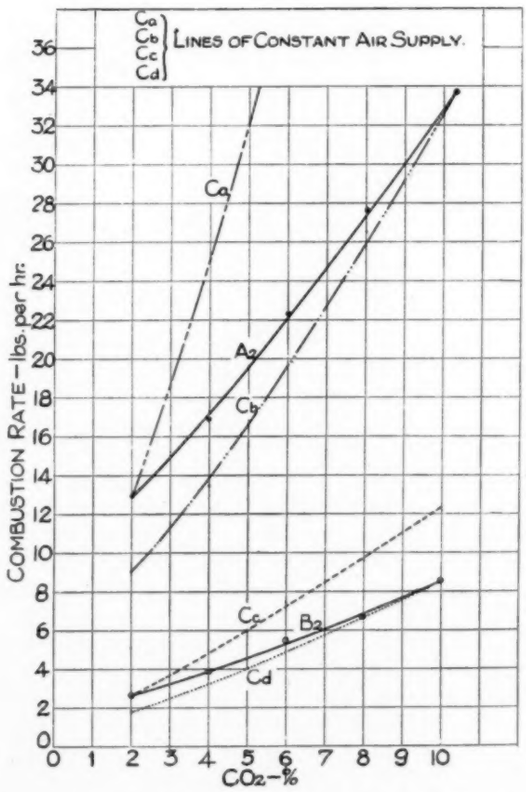


Fig. 4—Fuel-burning rates v. per cent CO_2, and lines of constant air supply

excess air shown (i.e., 50 per cent excess air). At 625 per cent of excess air the range is from 2.6 to 13 lb per hour, a spread of 10.4 lb compared to 24.4 lb at 50 per cent excess air.

Horizontal lines drawn through 8.4 and 13 lb, respectively, would enclose a zone where the rates of fuel burning between the above values could be achieved with any proportion of excess air from 50 to 625 per cent. On the other hand, the possible variation in excess air for a fuel-burning rate of 26.6 lb, for example, would be between 50 and 100 per cent. Burners chosen to operate somewhere near their maximum fuel-burning rates would practically dictate adjustments calling for low percentages of excess air.

While high fuel-burning rates would generally require decreases in excess air, low fuel-burning rates actually require increases in excess air. The penalties in the way of low efficiency at low fuel-burning rates are strikingly evident. The extreme range of this oil burner runs from 2.6 on Curve B_2 to 33.7 lb on Curve A_2, curve A_7 not being considered because of its different furnace draft. It is obvious that a range from 8.4 to 33.7 lb would be economically more desirable because any fuel-burning rate between these values could be managed with only 50 per cent of excess air.

Fig. 2 shows the results plotted with CO_2 instead of excess air. It will be noted that 2 per cent CO_2 is obtained with an excess air of 625 per cent and 10 per cent CO_2 at 50 per cent excess air. The range from 2 to 10 per cent CO_2 seems ample although probable values above 10 per cent CO_2 may be estimated by extending the curves. The extension of the curve beyond actual test points is not recommended, however.

Certain interesting things may be shown in other cases that do not appear in these tests. It might happen with another burner that the fuel-burning rate with maximum air could not be carried all the way to 10 per cent CO_2. This might mean a limitation possibly due to having reached maximum fuel capacity or due to operating difficulties caused by furnace proportion or design. The factor or factors contributing to this limitation could be found by study and a better balance of oil, air and furnace design achieved.

Again, limitations in the low fuel-burning rates might be traced to fuel preparation or to mixing or to furnace design. Furthermore, if standards of operation are ever adopted, curves like A_2 and B_2 would establish the boundaries for determining the operating range of any particular burner.

Figs. 3 and 4 show a very interesting characteristic which may or may not be common to other mechanical draft burners. Curves A_2 and B_2 in Figs. 1 and 2 were obtained by wide-open and completely closed air adjustments, respectively. The supposition would ordinarily be to the effect that the air supplied by the fan would be practically constant for each air adjustment. Curves C_a, C_b, C_c and C_d are lines of constant air supply.

Curve C_a was based on the air supply actually available at the point of maximum excess air on Curve A_2. C_b was based on the air supply actually available at 50 per cent excess air on Curve A_2. C_c and C_d were similarly determined for corresponding points on B_2. These curves merely indicate the fuel-burning rates that should be attained at various percentages of excess air if the air supply (*i.e.*, pounds per hour) is the same in each case. The curves are merely based upon combustion calculations.

These clearly show that, with an increase in excess air and the resultant decrease in fuel-burning rate, the air supply for Curves A_2 and B_2 actually do not remain constant even though the air adjustment is untouched.

A possible explanation for this would be that the density or volume of the fuel vapor might act as a barrier or in some other manner to reduce the flow areas ordinarily used by the air. That some throttling or holding back of the air takes place seems evident enough. The result shown by Curves A_2 and C_b indicates that if the air supply necessary for a combustion rate of 32.8 lb per hour at 50 per cent excess air had actually remained constant, a combustion rate of only 7.1 lb per hour would have been possible at 600 per cent excess air instead of the 13.1 lb actually obtained.

This suggests that if fan capacities are selected from regular fan test data, the volume of air available in actual operation might be seriously reduced and the anticipation as to probable maximum capacities thwarted. Curve

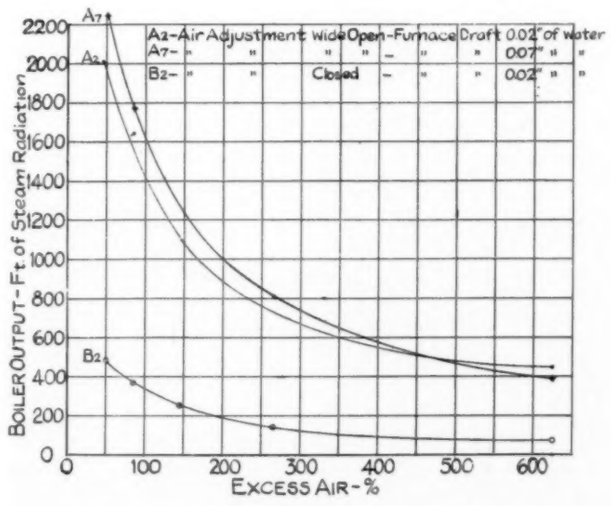


Fig. 5—Boiler output v. per cent excess air

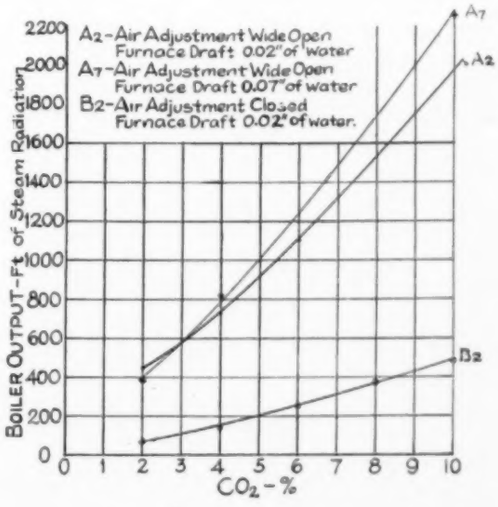


Fig. 6—Boiler output v. per cent CO_2

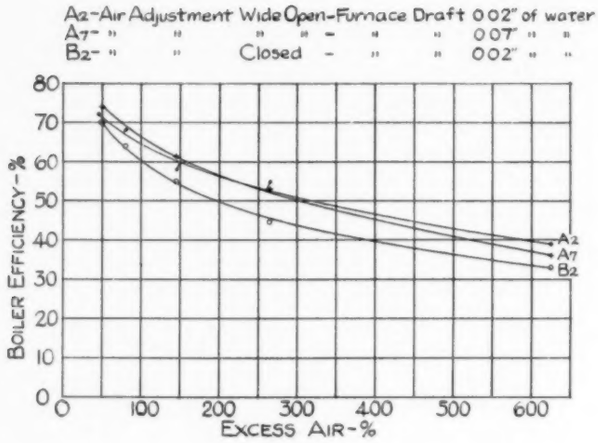


Fig. 7—Boiler efficiency v. per cent excess air

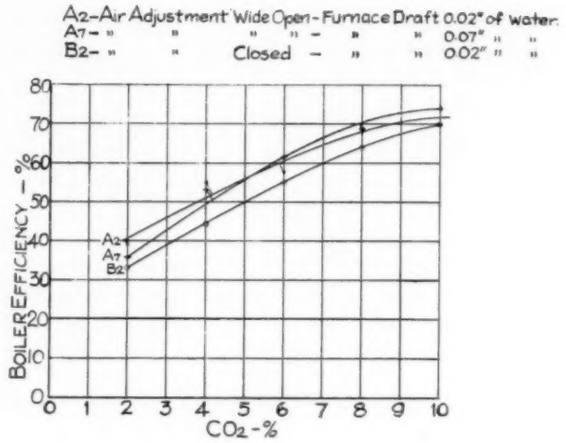


Fig. 8—Boiler efficiency v. per cent CO_2

C_a indicates what might have been expected from calculations as to maximum fuel-burning rates and Curve A_2 shows what would actually happen. Whether or not the effect of the fuel vapor, its method of delivery, and its combustion, is to reduce the air supply in every case as much as shown in these tests is not known. The question does arise as to whether tests of the character reported are valuable both experimentally and commercially.

Figs. 5 and 6 show the curves A_2, A_7 and B_2 plotted in terms of boiler output in feet of radiation (1 ft-rad = 240 Btu per hour) against excess air and per cent CO_2, respectively. This merely indicates what these fuel-burning rates mean in terms of actual heat output from the boiler. It should be clearly understood that boiler output values will depend upon the heat absorbing efficiency of the boiler and that these same tests conducted in another boiler might show different values and even some modification in the trends of the curves themselves.

Figs. 7 and 8 show the actual efficiencies obtained in these tests plotted against excess air and per cent CO_2, respectively. Fig. 9 shows the power requirements in curves for the fuel-burning tests reported in this paper. The curves, A_2, A_7 and B_2, are the power curves for the corresponding fuel-burning curves similarly designated. It will be noted that A_7 requires less power, probably due to the lower discharge pressure in the furnace. Curve B_2 shows that less power is required where the air supply rate is reduced. The fact that all of the curves are practically horizontal may or may not be typical. It is true that in following the curves from left to right the fuel rate decreases and the air rate increases and thus one factor may compensate for the other and the power remain practically constant. Actually, the power requirements of various oil burners are so very different, even at similar fuel-burning rates that generalizations are especially inconclusive.

Conclusions

1. Maximum fuel-burning range of an oil burner is obtainable, according to fixed operating standards, when the standard requires a low excess of air (or high CO_2).

2. The maximum fuel-burning rate at low excess air may be increased by increasing the furnace draft.

3. The possible variation in operating standards (*i.e.*, per cent of excess air) is reduced at the high fuel-burning rates. In other words, more economical fuel-burning conditions are assured.

4. There is a certain range in fuel-burning where it would be possible to have any excess of air from 50 to 625 per cent. The probable economy of fuel burning in this range would be highly speculative, assuming the absence of any standard of operation.

5. Very low fuel-burning rates make increases in excess air mandatory. Efficient fuel burning becomes virtually impossible.

6. The air delivery from the fan of the burner used in these tests falls off with an increase in the fuel-burning rate, even though the air adjustment remains fixed. To what extent this is a characteristic of all oil burners is not definitely known.

7. Any statement in regard to fuel-burning rates of an oil burner should preferably be qualified by operating standards relating to excess air (or CO_2) and furnace draft.

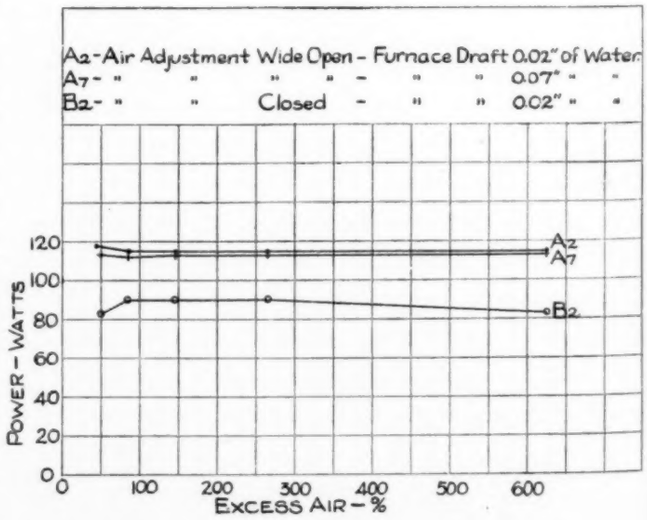


Fig. 9—Power requirements v. per cent excess air

Design and Valuation of Cast Iron Domestic Heating Boilers

By **Dr. Charles W. Brabbée*, *(MEMBER)*, New York, N. Y.**

EIGHT years ago the writer had the opportunity and honor to present some thoughts concerning the valuation of radiators in relation to human comfort. The idea has been further developed and several Universities are now working in this field. The Pierce Foundation Laboratory for Hygiene at Yale, completed a few months ago, also will conduct investigations of this character on heaters of different kinds.

Today it is possible to give the results of some fundamental boiler studies conducted during the past 25 years both here and abroad. It has been decided to open up the records of our company and present in broad lines some thoughts about boiler design and valuation, in order that the facts may be studied and by so doing possibly further advance the art. The field is so vast that, for the time being, a boiler group which is usually classified as "cast iron domestic heating boilers for solid fuels," has been selected for study though some remarks may refer to other products.

In some instances it has been customary to base the value of a boiler on its grate area, which is determined by grate width and length. Many years ago a European scientist, Engineer Barlach, made exhaustive studies of various combustion chamber designs which can be classified according to the three sketches in Fig. 1. He found that the design *B* with straight walls gave better combustion conditions than a wider grate *A* and that in turn the design *C* was better than *B*. Barlach went even so far as to design industrial stoves with only one grate bar, as in Fig. 2, and found that they burned wet fuels advantageously and gave better all around results. He attributed this fact to the high velocities of air and gas at the grate and to the complete spreading out of the combustion gases in the considerably widened fuel bed. Similar improvements were soon applied to European tile stoves. They often extended to the ceiling of the room and developed combustion efficiencies of 90 per cent. However, they concentrated their heat in the upper part of the room whereas the living zone was cold and uncomfortable.

It was in 1920 when the writer investigated such apparatus at the University of Charlottenburg, establishing at that time the measurement of the room temperature at three levels, namely, ceiling, eye and knee height.

In contrast with those old stoves, about 15 years ago tile stoves were designed in which the gases are first forced into a revertable flue, warming the lower tiles which face the room and then pass through an upflue into the chimney. Such stoves which used pinched grates to a considerable degree had not only a high combustion efficiency but also a high "Useful Output" into the living zone.

With open fireplaces it is often possible to prevent discharge of smoke into the rooms and to obtain better heating effects by using stones, according to Fig. 3, which perform the same duties as pinched grates.

American engineers, designing boilers, apparently had

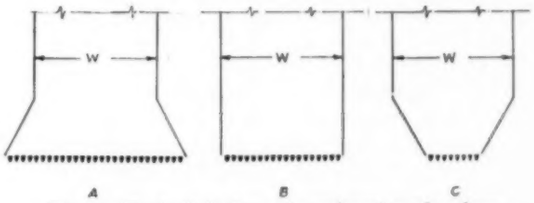


Fig. 1—Typical design of combustion chambers

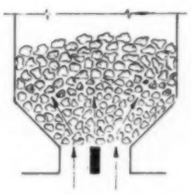


Fig. 2—Barlach grate

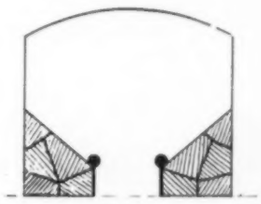
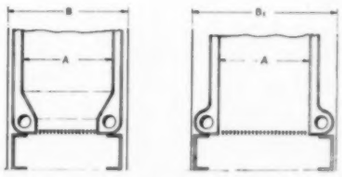


Fig. 3—Improvement on open fireplaces

a variation of such an arrangement in mind, namely, to locate the lower nipples conveniently (Fig. 4 and 5) without increase of the boiler's overall dimension *B*, which changes to B_1 if straight combustion chamber



Figs. 4 and 5—Pitched and straight boiler walls

walls are used. However, a pinched grate is only one item of many which influence a boiler's operation and there are several other points which should be considered, for instance: (1) total and free grate area, (2) construction of the grate bars, (3) dimensions of grate teeth, (4) the effect of teeth on front and back sections, (5) the arrangement of two grate bars in one center

*Director, Institute of Thermal Research, American Radiator Co.

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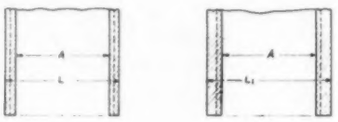
section, etc., but all this would distract attention from the main points.

Now consider the second important factor of grate area, namely the length A of the boiler in Fig. 6. Sometimes this dimension A is not measured directly but is taken as the lengths of the boiler L minus an arbitrary figure. Suppose the boiler of Fig. 6 is to be compared with the boiler of Fig. 7, the front and back sections of which are increased in depth so that the grate length A is the same, while the boiler length L_1 is now greater than L. Nothing has been changed in regard to actual performance fundamentals and yet boiler Fig. 7 would call for a higher rating. On the contrary, the latter



Figs. 6 and 7—Length of boilers different but combustion chamber equal

design is less desirable since the water content of front and back sections and also their iron weight have increased, which are disadvantageous to the boiler's action.

Going a step further, is the grate area of a boiler actually the most important item to be considered in boiler performance? Suppose the boiler in Fig. 8 is filled with coal from the grate line up to a certain height and this boiler is then connected to a given chimney.

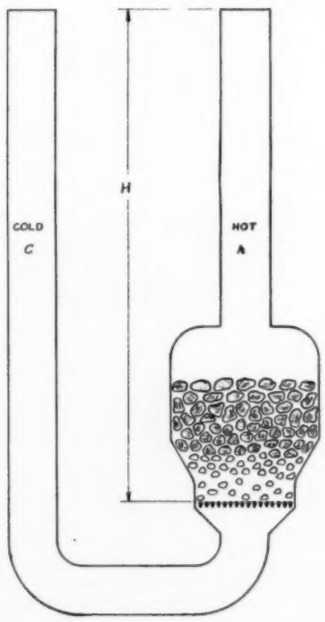
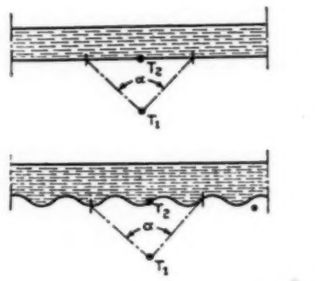


Fig. 8—Diagram of chimney action

The hot gases in the chimney form a hot column H against a cold column C of the outside air and of the same height H. The cold and heavier outside column forces gases out through the chimney.

It is, therefore, illogical to say that the chimney is drawing gases, it is rather necessary to state that the chimney delivers the gases which the cold outside air pushes through boiler and chimney. It will be observed that a given force created by the relative action of the hot and cold column, usually called the draft, must overcome not only the resistance of the grate but also all other flow resistances, especially the one of the coal layer, which is of the utmost importance. From these facts, we have justly to conclude that it would be appropriate to replace in this respect the grate area by the average area of the combustion chamber beginning at the grate line and ending at the top of fuel bed. As a more convenient and yet correct procedure the area of the combustion chamber taken at a certain height above the grate may be used.

The heat transmission in the combustion chamber is mainly by radiation from the hot firebed, whereas the influence of convection and conduction is often of lesser importance. Let us consider that the heat absorption of the firepot would be by radiation only, then flat com-



Figs. 9 and 10—Radiant heat transfer with straight and corrugated walls of the combustion chamber

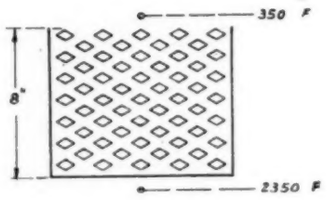


Fig. 11—Heat transfer with fins in flues

bustion chamber walls, according to Fig. 9, and corrugated ones, shown in Fig. 10, will produce the same heat transmission as long as T_1 (high temperature) T_2 (low temperature) and the apex angle α of the radiation cone are the same.

In consequence, fins in a firepot, will be found ineffective for heat transmission by radiation. However, fins and corrugations do have a beneficial action by conduction and convection and they may improve the supply of secondary air, thereby diminishing incomplete combustion.

When using oil burners with coal boilers, the heat transmission by radiation is often considerably decreased which explains, at least in part, some of the difficulties encountered with these installations. In all kinds of boilers and especially in those with restricted radiation in the fire-chamber, the heat transmission by convection and conduction is most important and governs the design and arrangement of the flue heating surface.

If hot gases are carried in a straight pipe it will be found that the gases cool off to a greater extent on the outer surfaces and remain relatively hot in the center resulting in poor heat transmission. Where stove pipes

are arranged with an L, undoubtedly by driving the stove at a high output it becomes red hot, indicating that very effective heat transmission takes place at that time. These facts disclose the secret of good heating surfaces. They must be so designed that in no way can stratification of hot gases take place, while the ideal must be to bring the maximum amount of hot gas particles into proper contact with the heat receiving surfaces. This rule is always important but most vital where only a comparatively small part of the total heat transmission takes place in the fire-chamber and, therefore, especially on oil boilers. Though the flues in Fig. 11 are comparatively short, they reduce the combustion temperature from about 2350 F, without any trouble, to 350 F. We have seen many visitors astonished when they look in the fire-box with its brilliance. and then touched the relatively cool smokepipe.

In fact, in some cases a part of this heating surface had to be eliminated because the gases cooled down too much and would, especially on water boilers and at low loads, come below the dew-point. This produced undesirable condensation in smokehood and chimney. Again another point has to be taken into consideration, namely, the cleaning of heating surfaces which may make it desirable to consider more favorable arrangements than shown in Fig. 11. Often it is heard that the cleaning of flues is unnecessary, though it is well known that a very thin soot layer covering the heating surfaces reduces their effectiveness considerably.

Sometimes it is possible to increase the effectiveness of a given heating surface by gas rotation, which is self-explanatory, as by such means more hot gas particles come into intimate contact with the cooler heating surfaces thereby increasing the heat transmission by convection and conduction. Unquestionably there is also in the flues of each boiler a certain amount of heat transfer by gas radiation, but for the specific conditions in domestic boilers this influence is small.

As the details of the heating surface are important for the boiler's performance, it might be well to discuss this item still further. What is "Heating Surface?" According to general practice in the field of domestic boiler, heating surface, for instance in a steam boiler, is defined as the surface on the one side of which is the fire or fire gases, whereas on the other side, is the boiler water. With such a definition only the surface up to level L in Fig. 12 may be called heating surface; however, actual boiler tests disclose that as soon as the water nears the boiling point fine sprays of water wet the inside of the heating surface above the water line. It has been found that such surface, called dry heating surface, as compared to the wet heating surface below the water line, is at least as effective as the latter and sometimes even more valuable.

Table 1 shows certain boiler tests, where the water line in a steam boiler was raised from 47 in. to 57 in. and the wet heating surface thus considerably increased. Tests 1 and 2 refer to the pickup operation of the boiler with an average output of 1,830 sq ft of steam radiation and it will be noted that the efficiencies in both cases: namely, with low and high water line, were exactly the same. Tests 3 and 4 show a similar investigation but with steady operation of the boiler and again it is seen that the efficiencies are equal both for low and high water

Table 1—Influence of Dry and Wet Heating Surfaces

Test No.	Average Approximate Output, Sq Ft Steam	Average Water Line Inches	Duration of Test Hours	Average Efficiency %	Remarks
1	1830	47	9.27	78	Pickup
2		57	9.61	78	State
3	1810	47	9.27	83	Steady
4		57	9.61	83	State

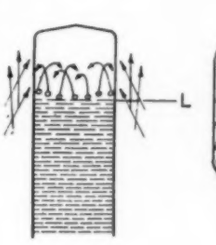
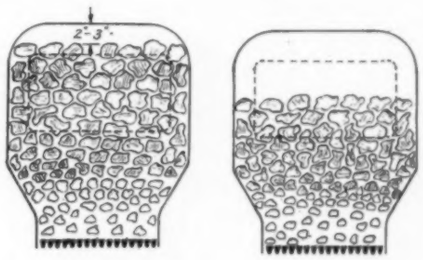


Fig. 12—Wet and dry heating surfaces



Figs. 13 and 14—Various fuel heights in a combustion chamber

line settings. From these tests it can be concluded that dry and wet heating surface properly arranged are equivalent in their action.

The importance of the term heating surface has often led to the belief that a boiler's performance improves in direct proportion to the amount of its heating surface. In order to see somewhat clearer in this respect, note Table 2, in which there is a comparison covering a great many investigations and in which typical cases are shown.

The study in Table 2 is made for each of two boilers arranged in five groups, beginning with very large ones of about 800 sq ft heating surface, then large boilers with about 400 sq ft heating surface, then medium boilers with about 200 sq ft heating surface, followed by small boilers of about 75 sq ft heating surface and finally comparing very small boilers with about 20 sq ft heating surface.

In the first group, boiler A has X sq ft heating surface, where boiler B has $X + 30$ per cent sq ft heating surface. The latter gave a maximum hourly output of only Y sq ft steam[x], while boiler A with much less heating surface, delivered a maximum of $Y + 50$ per cent sq ft steam. Boiler A had a stack gas temperature of 780 F, and boiler B at highest output 580 F, both boilers working on equal chimneys, 30 in. x 36 in. in size and 95 ft high. It is interesting to note that the boiler with less heating surface and with higher stack gas temperature had an efficiency of 68 per cent for the maximum output, 74 per cent for ⅔ and 78 per cent for ⅓ of this load, while the corresponding figures for boiler B with 30 per cent more heating surface were 68 per cent, 73 per cent and 76 per cent. Boiler B with its lower stack gas temperature could not develop sufficient draft and hence was somewhat handicapped. In addition, it was found that the low draft was responsible for insufficient supply of secondary air so that boiler B with its large amount of heating surface showed an average CO value of 2 per cent whereas boiler A produced only 0.4 per cent average CO, and it is known that each 1 per cent increase in CO reduces the efficiency 4 to 5 per cent. In con-

[x]1 sq ft steam = 240 Btu hr.

Table 2—Comparison of Characteristics of Large and Small Boilers in Respect to Output, Heating Surfaces, Weight, Efficiency, etc.

Boiler							Efficiency (%) for			
Max. H. S. Sq Ft	Name	Actual H. S. Sq Ft	Max. Output Sq Ft Steam 1 Sq Ft = 240 Btu/Hr	Av. Stack Temp. Max. Output F	Chimney Data Area = Sq In Height = Ft	Weight Lb	Max. Output	2/3 of Max. Output	1/3 of Max. Output	Remarks
800	A	X	Y + 50%	780	30 x 36	Z	68	74	78	Steam—Anthracite
	B	X + 30%	Y	580	95 Ft	Z + 23%	68	73	76	Average CO %....0.4
										Max. Output.....2.0
B 30% more H. S. 23% more weight. A Better efficiencies, through higher stack gas temperature. 50% more reserve capacity in output.										1% CO = 4 to 5% in Efficiency.
							Max.	2/3	½	
400	C	X	Equal	815	20 x 20	Z	71	76	78	Steam—Anthracite
	D	X + 78%		595	60 Ft	Z + 30%	71	74	75	Average CO %....0.2
										Max. Output.....1.0
D 78% more H. S. 30% more weight. C Slightly better efficiencies, though much higher stack gas temperature. Same maximum output.										
							Max.	2/3	½	
200	E	X	Equal	570	12 x 16	Z	78	82	81	Steam—Anthracite
	F	X + 40%		680	45 Ft	Z + 15%	78	82	80	Average CO %....0.1
										Max. Output.....0.15
F 40% more H. S. 15% more weight. E Equal efficiencies—same maximum output.										
							Max.	2/3	⅓	
100	G	X	Equal	510	12 x 12	Z	80.5	80.5	80	Steam—Coke
	H	X + 35%		520	45 Ft	Z + 12%	79	81	78	Average CO at Max. Output—equal
H 35% more H. S. 12% more weight. G Efficiencies at maximum and ½ load slightly higher. Same maximum output.										
							Av. Load	½ Av. Load		
25	K	X	Y Sq Ft Water 1 Sq Ft = 150 Btu/Hr	705	8 x 8	Same Weight	74.5	70.0		Water—Coke
	L	X + 17%	Y − 14%	910	35 Ft		72.3	64.9		Average CO at Max. Output—equal
L 17% more H. S. 14% less maximum output. K Efficiencies considerably better. H. S. = Heating Surface										

clusion, it is to be said that boiler A is a better boiler than B which has 30 per cent more heating surface, a 200 F lower stack gas temperature and 23 per cent more weight.

Similar results are disclosed in the other groups as can be seen from Table 2. In order to save time note the smallest products compared. Boiler K has a certain amount of heating surface *X*, whereas boiler L has *X* + 17 per cent heating surface, yet boiler L shows 14 per cent less maximum output. It was found in this case that the surplus heating surface was ineffectively arranged so that the average stack gas temperature of the boiler L at maximum output was 900 F, while boiler K with less heating surface and more output gave 700 F stack gas temperature. Both boilers had the same weight. They were connected to chimney 8x8-in. and 35-ft height. However boiler K had at average load 74.5 per cent efficiency against 72.2 per cent for boiler L and at 50 per cent of the average load, the former realized 70.0 against 64.9 per cent.

It will be noted therefore that it is not correct to classify, rate and sell domestic cast iron boilers according to their heating surface. It may further be concluded that the judgment of boilers based upon their stack gas temperatures leads to erroneous results, especially if the influence of the products of combustion (CO_2 and CO) is neglected.

In this latter respect, the following facts found in actual tests may prove to be of interest. One boiler A was first fired according to Fig. 13 with the fuel crowded into the fire-box up to a few inches from the crownsheet, which is customary in laboratory investigations. After this the same boiler was filled to the middle of the fire-door only, as depicted in Fig. 14.

The diagram Fig. 15 refers to the first mentioned method of firing up to the crownsheet and gives:

an average CO_2 content of 13.9 per cent
an average CO of 0.6 per cent
and an efficiency of 70.0 per cent

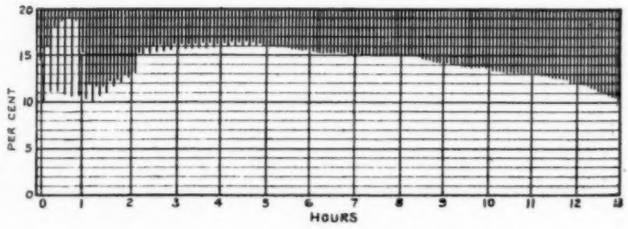


Fig. 15—Mono diagram with high boiler filling
CO_2, 13.9%; CO, 0.6%; *e*, 70.0%

In contrast to this diagram Fig. 16 shows the condition when the same boiler was filled only to the middle of the fire-door.

It indicates:

an average CO_2 content of 13.9 per cent
an average CO content of 0.2 per cent
and an efficiency of 72.5 per cent

which is easy to understand if it is recalled that the increase of 1 per cent in the CO content of the stack gases reduces the efficiency from 4 to 5 per cent.

Indeed these facts should be most carefully considered

and the author is convinced that in so doing one will arrive at a new, or rather old item, namely, the Useful Service of a boiler. Regarding this Useful Service the writer would like to summarize his experience briefly as follows:

1. A boiler must be able to deliver in the morning the necessary output easily and quickly, also under the most exacting and severest conditions of rapidly changing weather.
2. A boiler with too much heating surface and therefore a too low stack gas temperature will, even with laboratory efficiencies of 80 per cent, be unsatisfactory if its chimney cannot develop the draft necessary to obtain quickly the required high output.

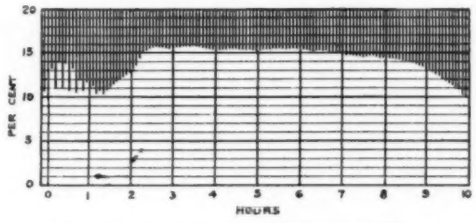


Fig. 16—Mono diagram with boiler filling to middle of fire-door
CO_2, 13.90%; CO, 0.20%; e, 72.5%

3. A boiler must be able to do such emergency work even with the poor chimney conditions frequently encountered in actual practice.
4. Replacement of a highly efficient boiler by one which has 2 or 3 per cent less efficiency is not only justified very often but works in the direction of higher "Useful Service," as it gives easily and quickly everything that the consumer wants and with satisfactory fuel consumption.
5. The economical operation of a house heating plant is less influenced by the boiler's efficiency during severe weather than during the many weeks when the system works at one-half or one-third, or even less of its rated capacity.
6. During those times correctly selected boilers need attention only at long intervals despite the fact that the combusion chamber is never filled up to the crownsheet. The boiler then works with a relatively shallow fuelbed, with low stackgas temperature and without CO, performing differently than under certain official test conditions not experienced in the field.

A few words related to certain flue arrangements found on coal boilers here and abroad may be of some interest.

Boiler flues are either arranged according to Fig. 17 where the gases continue their way upward from the fuel bed to the chimney or they can be arranged according to Fig. 18 where the gases have to pass through a down or revertable flue. Boilers of the latter type often have a large amount of heating surface and show low stack gas temperatures and high efficiencies in the laboratory .

However these boilers are sometimes difficult to start if a bypass is not provided, which connects directly for a certain time combustion chamber and chimney, and which offers, especially in relatively warm and damp weather and with poor chimneys, great conveniences. How important such a device is may be learned from publications in Europe which reveal the following facts:

A boiler with revertable flues (Fig. 19) was installed and connected with an under floor breeching to a distant chimney. When first fired in mild Fall weather or after longer recesses during an advanced Spring the kindling

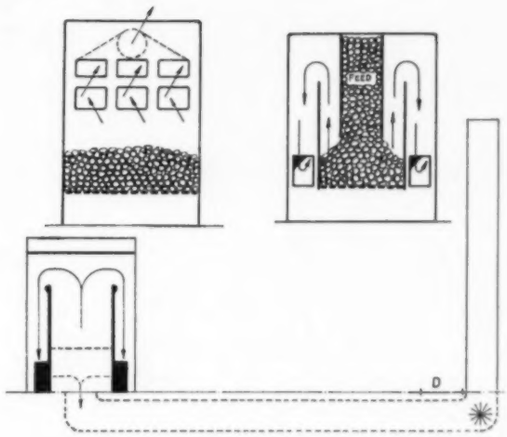


Fig. 17—Updraft flues Fig. 18—Downdraft (revertable flues) Fig. 19—Underground flues

wood, on top of which was a layer of coal, began to smoke considerably. This is quite understandable as the chimney which was wet due to rain, could not develop any draft on account of the very low stack gas temperature then prevailing.

To remedy this condition the janitor opened the cleanout D in order to start a paper fire at the bottom of the chimney and in so doing was overcome by the products of incomplete combustion present at that point.

Many more important items could be brought up for discussion as for instance; detrimental action of gas leakage between boiler sections, beneficial influence of iron to iron joints and accurate machining, short circuiting of gases through the boiler, water capacity at waterline, disengaging areas and steam dome volume, foaming and priming, fluttering of flames in airtight oil boilers,

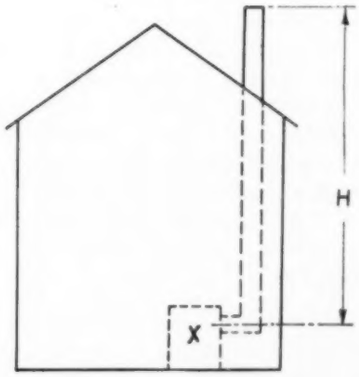


Fig. 20—House, boiler and chimney

steam water mixtures and other items as: application of pressure or suction in boilers, buckwheat and soft coal boilers, smokeless combustion and so on. However, as time does not permit discussion in such matters, certain suggestions which we think are of more general interest, will now be made.

Fig. 20 shows in diagrammatical form a house equipped with a given chimney of certain dimensions and a definite height H. Boiler X is brought into this house and with the chimney provided must deliver a requested maximum amount of heat units. Following

Table 3—Chimney Table
Anthracite Coal

Maximum Boiler Output, Sq Ft		Chimney	
Steam	Water	Size, Inches	Height, Feet
250 to 500	350 to 800	8 x 8	30
500 to 1000	800 to 1600	8 x 12	35
1000 to 1500	1600 to 2400	12 x 12	35 to 40
1500 to 2500	2400 to 4000	12 x 16	40 to 45
2500 to 3500	4000 to 5600	16 x 16	40 to 50
3500 to 4500	5600 to 7200	16 x 20	50 to 55
4500 to 6500	7200 to 10000	20 x 20	50 to 60
6500 to 9500	10000 to 15000	20 x 24	60 to 75
9500 to 12500	15000 to 20000	24 x 28	75 to 85
12500 to 15000	20000 to 24000	30 x 30	85 to 100
15000 to 20000	24000 to 32000	30 x 36	90 to 115
20000 to 25000	32000 to 40000	36 x 36	110 to 125

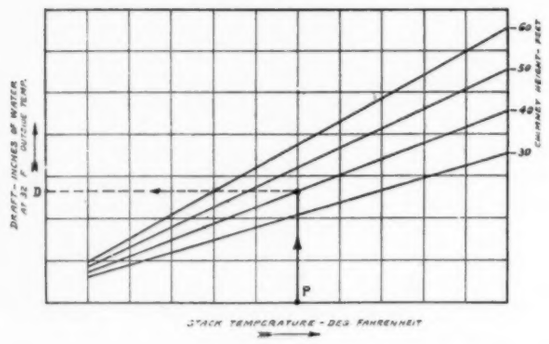


Fig 21—Draft diagram

out this plan, Table 3 has been compiled from practical observations and shows chimney sizes and heights as a function of the boiler's maximum output.

The diagram Fig. 21 has been developed in which the theoretical draft is shown for a given outside temperature (of for instance 32 F) as a function of the chimney's height and of the stack gas temperature at the boiler's outlet.

This draft however is theoretical and cannot be obtained in actual practice because many items reduce its value, especially the cooling effect and leakage of the chimney. One can then go into statistical search and find that for practical conditions only a certain fraction of the theoretical values can be safely counted upon. With such a practical chart which could be developed there would be only one more thing necessary to solve the problem completely. This one thing is a table such as Table 4 in which the boiler manufacturer gives among other data, the following six items:

1. Outputs.
2. Stack gas temperatures.
3. Chimney sizes and heights.
4. Draft requirements.
5. Efficiencies.
6. Time available fuel will last.

With such information the procedure is self-evident.

A. Determine maximum boiler load,
B. Follow the vertical column at that load until you find the boiler you like for its efficiency, for its stack gas temperature, for its attendance period, or for any other reason,
C. Check, if for that boiler, the chimney data coincide with the standard chimney table,
D. Note the stack gas temperature and chimney height and check if the requested draft is actually available as taken from the draft diagrams.
E. Under otherwise equal boilers, that one is the best which shows for one-half or one-third of its rated capacity most favorable characteristics for practical use.

Looking backward over the years consider what was known of boiler design and what progress has been made in scientific research and in practical manufacture. Let us not forget one point of great importance, namely, the presentation of our engineering products to the public. Formerly thrown into a dark part of the cellar the boilers indispensable for comfort and health, present themselves today as items of specific attraction (Fig. 22).

To review the items just discussed in connection with boiler design does it not appear as though the former standards of boiler selection; weight, grate area, heating surface, etc. must give way to the requirements of actual practice, namely, requested amount of heat and good efficiency under given draft conditions.

Table 4—Boiler Selecting Table

BOILER NUMBER	OUTPUT IN (1000 s) B.T.U. PER HR.	90	102	114	126	138	150	162	174	186	198	210	222	234	246	270	294	318
	OUTPUT-STEAM RADIATION SQ. FT.	375	425	475	525	575	625	675	725	775	825	875	925	975	1025	1125	1225	1325
X-S-4	ATTENTION PERIOD HRS.	19.7	17.7	15.8	14.4	13.3	12.3	11.4	10.6	9.8	9.3	8.7	8.3					
GRATE AREA	EFFICIENCY %	77.0	77.5	78.0	78.0	78.0	78.5	78.5	78.5	78.5	78.0	78.0	78.0					
SQ. FT.	STACK GAS TEMP. °F	305	320	335	350	365	380	395	410	425	440	455	470					
FUEL CAP	GRATE LOAD PER SQ. FT./HR. LBS.	2.7	3.0	3.3	3.6	4.0	4.4	4.8	5.1	5.5	5.8	6.1	6.4					
LBS.	DRAFT REQUIRED IN. WATER	.027	.032	.037	.045	.052	.058	.062	.068	.075	.085	.095	.105					
ATTENTION	CHIMNEY SIZE INCHES	8x12	8x12	8x12	8x12	8x12	8x12	8x12	8x12	8x12	8x12	8x12	8x12					
FUEL-LBS.	CHIMNEY HEIGHT FEET	35	35	35	35	35	35	35	35	35	35	35	35					
X-S-5	ATTENTION PERIOD HRS.			18.0	17.6	16.1	14.8	13.7	12.7	11.8	11.2	10.5	10.0	9.5	9.0	8.5		
GRATE AREA	EFFICIENCY %			78.0	78.0	78.5	78.5	78.5	79.0	79.0	79.0	79.0	79.0	78.5	78.5	78.5		
SQ. FT.	STACK GAS TEMP °F			305	320	335	350	365	380	395	410	425	440	455	470	485		
FUEL CAP	GRATE LOAD PER SQ. FT./HR. LBS.			2.6	2.9	3.2	3.5	3.8	4.1	4.3	4.6	4.9	5.2	5.4	5.7	6.2		
LBS.	DRAFT REQUIRED IN. WATER			.037	.043	.048	.053	.060	.067	.073	.078	.083	.087	.095	.107	.120		
ATTENTION	CHIMNEY SIZE INCHES			8x12	8x12	8x12	8x12	8x12	8x12	8x12	8x12	8x12	8x12	8x12	8x12	8x12		
FUEL-LBS.	CHIMNEY HEIGHT FEET			40	40	40	40	40	40	40	40	40	40	40	40	40		
X-S-6	ATTENTION PERIOD HRS.					18.5	17.4	16.3	15.3	14.3	13.3	12.6	11.8	11.3	10.7	10.0	9.1	8.3
GRATE AREA	EFFICIENCY %					79.0	79.0	79.0	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.0	79.0	79.0
SQ. FT.	STACK GAS TEMP °F					315	330	340	350	365	375	385	395	405	420	440	465	490
FUEL CAP	GRATE LOAD PER SQ. FT./HR. LBS.					2.8	3.0	3.2	3.4	3.6	3.9	4.1	4.3	4.6	4.8	5.2	5.6	6.2
LBS.	DRAFT REQUIRED IN. WATER					.043	.047	.050	.053	.060	.067	.072	.077	.082	.087	.097	.113	.123
ATTENTION	CHIMNEY SIZE INCHES					8x12	8x12	8x12	8x12	8x12	8x12	8x12	8x12	8x12	8x12	8x12	8x12	8x12
FUEL-LBS.	CHIMNEY HEIGHT FEET					40	40	40	40	40	40	40	40	40	40	40	40	40

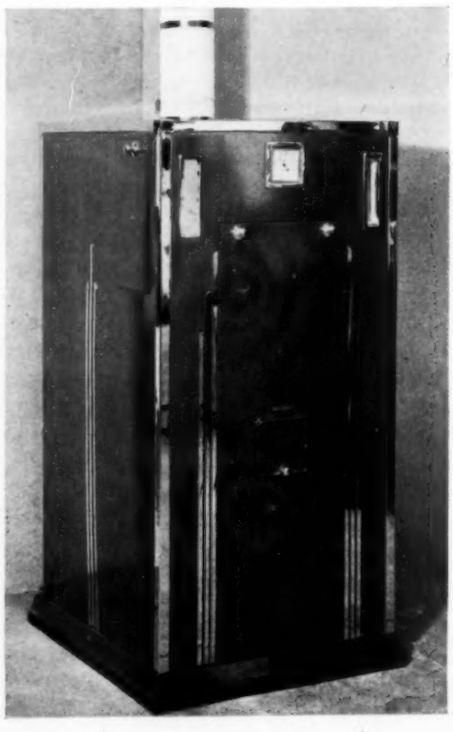


Fig. 22—Modern boiler design

Engineering in the Hospital of Tomorrow

By **Charles F. Neergaard,* *(NON-MEMBER)*, New York, N. Y.**

AT A recent meeting of the New York Chapter of this Society the writer presented a paper which ventured to challenge certain commonly accepted principles of hospital engineering. Consequently the critic has been invited to turn creator and formulate the type of plant the hospital should have and what it should accomplish.

There are many chapters in the history of hospital engineering which are chapters of extravagance and error. The hospital's stated requirements have often been contradictory and many of its mechanical standards built up on fallacious theories, rather than on scientific analyses of precise needs. While the hospital is a laboratory for medical research it should not be the subject of mechanical experimentation. Its mechanical plant has become so elaborate and complex that the cost for installation, operation and maintenance is oftentimes indefensible. Yet new refinements and luxuries are constantly being urged. The ideal plant is one where each feature is designed with calculated simplicity to do its job adequately, regularly and economically.

The major problem in the hospital world today is the financial problem. During the depression demands for free care have fast multiplied while earnings and contributions have fallen to an alarming extent. It is the theory of the French savant, Abbé Le Maitre, that the universe is expanding and collapsing at the same time. With the hospital this is a condition, not a theory. There is many a tragedy in excessive but irreducible cost of plant operation, where every dollar wasted in the power house means a dollar less for the care of the patient.

The mechanical plant holds an important place in the financial picture. On the basis of average experience a 100 bed general hospital in the New York area built in 1930 would have required an investment for building and fixed equipment of some $650,000, of which about $200,000 would be represented by power, heat, plumbing, ventilating, elevators, sterilizers, kitchen and laundry equipment and electrical services. In 1932 the hospital would have spent $160,000 to operate in which would be included only the actual cost of replacements and repairs, but a small percentage of the inevitable reckoning for depreciation and obsolescence. In the figures of 30 New York City hospitals for 1932 there was a spread of from 3c to 9c of the expense dollar for fuel, power and light alone. Thus the 100 bed hospital, if it had an economical plant, might spend as little as $4,800 for these essentials or if handicapped with an extravagant one, as much as $14,400.

Whatever may be said of the qualifications of the operating engineer, scientific planning and sound judgment can build into a plant operating economies which will be constant and largely inescapable. The cost of the hospital structure and the cost of hospital operation have increased to a point where it is imperative that our thoughts be in terms of major economic reforms.

The hospital needs the same promise of salvation as is appearing on the railroad horizon, where revolutionary changes in design and construction are producing streamline passenger trains of one-third the weight which have 50 per cent greater speed at half the operating cost of those they replace.

In the light of past experience and present knowledge of planning, construction and equipment, and based on hope, perhaps, rather than prophecy, the hospital of tomorrow is going to be built at from 25 per cent to 40 per cent less cost than the hospital of 1930, given the same labor and material levels. The fixed charges for operation and maintenance, interest and insurance, must be reduced in even greater ratio.

While it is not within the province of this paper to anticipate architectural evolution, it will be necessary to blaze the way in certain particulars, to establish the requirements for the mechanical plant. The 100 bed hospital structure will be smaller than its 1930 prototype, lighter, more compact, quieter, longer lived, and with a better insulated envelope. The mechanical services, simpler and more efficient, will provide better conditions for patients and those who care for them.

The building will be smaller through the elimination of waste space and waste cubage and because of fewer beds needed in reserve. The supreme quality of elasticity in the plan will make it possible for a hospital with 100 beds to meet the demands of a district where an average of 85 patients require bed care, for which in the past 130 beds have been provided.

The building will be lighter, fireproof with a welded steel frame, the steel tonnage being radically reduced by the use in walls, partitions and floor slabs of light cellular concrete. This weighs from 40 to 70 lb per cubic foot depending on requirements, yet has ample strength.

In addition to its reduction of the dead load, cellular concrete *for walls* presents the advantage of lower heat conductance and higher specific heat than most other insulating materials: *for partitions,* effective insulation against sound transmission in minimum space, a 4-in. block plastered both sides having a coefficient of some 38 decibels. Thus a "sound proof" partition of 5½ in. replaces one of 8½-in. thickness; *for floor slabs,* poured in 4 ft spans, it provides effective sound insulation between the floors. The cinder fill will be omitted. This in the past has served to cover irregularities in pouring the arches and to conceal the pipes and conduits no

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*Hospital Consultant.

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longer to be run in the floor structure. The usual separate screed coat will be unnecessary as the expansion of this concrete when poured can be controlled within a quarter of an inch and the floor slab itself, in a single operation, rolled and finished to a smooth level surface, ready to receive the finished flooring.

The building will be more compact. Scientific planning will apply the principles of industrial efficiency in every department to minimize waste space, waste motion and waste effort.

The building will be quieter. Sound insulating partitions and the liberal use of acoustical treatment will confine and absorb internal noises at the source. Quiet operation will be a prerequisite for every piece of equipment and all engineering specifications will contain a covering clause binding on the manufacturer and general contractor that noise is a defect which will lead to rejection. All noise is relative and a fair acceptance test difficult to formulate without assurance of adequately insulated bases and acoustical treatment.

The building will have a better insulated envelope. Buildings today are structurally wrong when air leaks through the walls like sieves. Infiltration of 30 to 60 cu ft of air per minute around windows is not exceptional. Now with the steel frame a curtain wall replaces the bearing wall; thin ashlar simulates massive masonry; thermal insulation is conspicuous by its absence. As it carries no load, the ultimate wall may be a thin wall, insuring maximum hours of precious sunlight in each room. It will be a wind and weather proofed overcoat with an inside lining which will feel warm and hold the building's body heat.

Some day the entire exterior may be faced with aluminum, copper or stainless steel, reflecting 95 per cent of the sun's heat. But for the present it will be necessary to be content with conventional brick or stone veneer effectively waterproofed with a backing of cellular concrete block and an inch or so of insulating material of low thermal conductivity. Whatever insulation is used,—rock wool, metal foil, rock cork, cork board, gassed rubber or some material as yet in the laboratory stage,—the conductivity of the wall should be less than half that of the present standard masonry construction. In the roof equally effective insulating measures will be used.

Eventually the ideal wall will be designed. It should heat up quickly, in minutes, not hours, after the window is closed on a winter morning, and feel warm all day, for warm wall surfaces are fully as important to health and comfort as proper warmth and moisture in the air. There will be no plaster. The walls and ceilings will be of panels finished with synthetic resin of whatever color desired, resistant, permanent, washable, and the painting problem will cease to be.

Windows: The pioneer studies of Voorhees and Meyer on "Window Leakage" and later reports from the A.S.H.V.E. Research Laboratory and the cooperative work at the University of Wisconsin have demonstrated the extravagance of poor windows. Hospitals have found the solid steel pivoted window highly satisfactory. The sash, closing against felt gaskets, shows negligible leakage. The felt cushions absorb vibrations, exclude street noises, act as shock absorbers in reducing breakage, and show little deterioration after 15 years.

A major problem as yet unsolved, is a simple and economical control of heat loss through window glass. If double glass can be produced, parallel sheets fused with glass spreaders, forming an air space, filled with a dry gas, *e.g.* carbon dioxide, at atmospheric pressure, there will be a high degree of insulation and no condensation. Research should sooner or later produce a commercial product for which there will be a large market.

With walls and windows as described the radiation in the building may be reduced from one-half to one-third of what is now used and the boilers proportionately. The additional cost of the insulating measures should not exceed the resulting cut in the cost of the plant. The fuel saving will be an annual extra dividend.

Air Conditioning

Perhaps the most popular recommendation which could be made for heating and ventilating the future hospital would be to turn the entire problem over to the air conditioning engineer and let him install a central plant with a robot in the engine room surrounded by registering and recording gauges, and instruments of precision, with which to regulate all of the elements of heat and cold, moisture and clean air throughout the building. Admittedly the hospital of the future must have better air. It must keep pace with the findings of the physiologist and provide whatever will contribute to the safety or cure of the patient, but every item of increased expense must be conclusively vindicated.

The present trend in central air conditioning does not appear to be in conformity with the hospital's pocketbook. An office building erected in 1932, comparable in bulk to a 300 bed hospital, with an air conditioning plant, then conceded to represent the most advanced ideas, will serve as an example. The heating system is entirely separate from the air conditioning. In each room conditioned air is introduced in a horizontal stream through grilles at the top of the inside partition and circulation maintained through exhaust ducts similarly located. Many protesting tenants have defeated the plan that all windows be kept locked. It is evident that complete abandonment of the open window must be deferred until human nature has changed more than a little.

The building has 10 zone fan rooms. There are 15 fan and two pump motors ranging from 3 to 25 hp with a total of over 100 hp. The compressor motor of the 300-ton refrigerating unit is 250 hp. If the building were a hospital, this would mean a ton of refrigeration and more than a horsepower motor capacity for each bed.

Applying the experience of this building to a hospital is illuminating although the hospital figures are more suggestive than accurate, as shown by Table 1.

On this basis the 300 bed hospital would spend $137,500 to install central air conditioning, or 7 per cent more than 1930 construction costs ($6,500 a bed). The $23,000 additional for operating expenses would represent an increase of 80 per cent over the average expenditure in 1932 for fuel, light and power ($96 a bed).*

The hospital is in hearty sympathy with the ends and ideals of air conditioning but the present cost levels are beyond its reach. Any other conclusions would be incon-

*Average annual operating cost $1600 per bed. Fuel, light and power 6 per cent, or $96 a bed.

Table 1—Estimate of the Installation and Operating Cost of Heat and Ventilation in a Hospital with and without General Air Conditioning Based on the Plant in an Office Building with 3,000,000 cu ft of Construction and Floor Areas Sufficient to House a 300 Bed Hospital

The office building is in use 8 hours a day, 5½ days a week, the hospital 24 hours a day, every day in the year.

	Office Building	Hospital Without Air Conditioning	Hospital Equipped With Air Conditioning
Installation Cost			
Heating Plant	$ 68,000	$68,000	$ 68,000
Air Conditioning	165,000	.....	150,000
Exhaust Ventilation	7,500	20,000	7,500
Total Investment	$240,700	$88,000	$225,500
Operating Cost Omitting Labor			
Fuel and Supplies Heating	$ 6,100	$15,000	$15,000
Power and Maintenance			
Air Conditioning	17,000	.....	25,000
Ventilating	1,000	4,000	2,000
	$24,100	$19,000	$42,000

sistent with the purpose of this paper which is admittedly to commandeer the ingenuity and skill of the members of this Society and the resources of its research facilities to the end that the hospital may be enabled to house and care for its patients without having to spend so much money. The late Bill Guard's brief definition of the Einstein theory, "There is no hitching post in the universe" is suggestive of how far the engineering profession can be expected to go to achieve so worthwhile an end.

New Mechanical Plant

In suggesting mechanical desiderata for the hospital of tomorrow from the user's standpoint the author does not hesitate to project theory beyond current practice as it will be the engineer's responsibility, not his, to bridge in some effective manner any gaps between present procedures and future ideals. As crystal gazing is essentially foreign to engineering it has been the aim in this structural and mechanical synthesis to forecast only things which have been done, are about to be done, or reasonably should be done.

The premise seems admissible that with the New Deal, the mercury boiler, power pools and hydro-electric expansion the hospital may anticipate cheaper electric power.

The power plant of the past has been a considerable industry in itself, heavily subsidized by the hospital. The operation and care of high pressure boilers, steam mains, pumps, valves, traps, heaters, water treatment, requiring two or three shifts of licensed engineers and firemen, has constituted perhaps the greatest source of worry and uncontrollable expense to the management. But why a high pressure plant? Few hospitals generate electricity and but little high pressure steam is really used. Consider the picture. To supply the usual steam requirements for a 100 bed hospital most engineers have logically installed two 150 hp boilers, one a spare—a few conservatives, two of 100 hp.

The use of equipment in the last three items of Table 2 is exceedingly irregular so that in the absence of actual records the estimated hours of full load can only be approximated. Obviously even a 100 hp boiler would rarely be overloaded except in extremely cold weather, yet 100 lb steam pressure must be maintained a large

Table 2—Summary of Steam Requirements

Use	HP Needed	Steam Pressure Needed	Daily Hours at Full Load
General heating system	90	5 lb	24 hr
Special heating, operating and delivery rooms	3	5	8
Domestic hot water supply	20	5	16
Laundry	15	100	6
Kitchen and dishwashing	10	20	6
Sterilizing	15	40	5
Total	153		

portion of each day with a waste, particularly in the summer months, which is not cheerful to contemplate.

In the Hospital of Tomorrow the high pressure plant is practically eliminated. Its passing is due partly to its high cost and poor adaptation to hospital needs, but more as a natural consequence of engineering developments which have and will, make available new and more efficient equipment, accomplishing better, at less cost, what the hospital requires. Much of the equipment will be operated by gas and electricity. With the old system will depart the wastage from overheated buildings, heat losses and leaks in mains, drips, pumps, traps, valves, etc., which with the heavy engine room payroll have contributed so largely to the red ink total.

The hospital has found hot water heat to be the most comfortable and satisfactory. With a properly designed plant, it will heat a given building, engineers assert, at less cost than any other appropriate system. The new heating will be of the forced hot water type, with water carried at somewhat higher temperature than present practice, to permit of smaller radiators and piping, with a range from a normal of 140 deg to a high of 220 deg on the occasional zero day. Thanks to well-insulated walls, double glass and hotter water, the radiators of a type giving the maximum of radiant heat will be approximately one-half to one-third the size of those now in use. They will be recessed under the windows but not enclosed. As the temperature of the water and heat levels throughout the different parts of the building will be regulated in the boiler room, all radiator traps and valves (except key shut-off) will be omitted. What this will save may be judged from the fact that in a 100 bed hospital studied, there were 260 radiators with 520 valves and traps. In patients' rooms and wherever warranted there will be a supplementary local control,—a little unit which will be called a "booster"—under the radiator, both concealed by a small removable facia. It will consist of a small fan, a fresh air inlet, removable filters and a damper mixing fresh and recirculated air in desired proportions. It will be similar in principle to the unit ventilator but smaller, simpler and far less expensive. The fan, about 1/20 hp, will be noiseless, dependable, but cheap,—preferably not electric,—perhaps compressed air. The booster, when started, will increase the temperature of the room by speeding up the circulation of air over the radiator, or cool the room by drawing in air from outside. It will run only semi-occasionally when the occupant desires more or less heat than the normal provision, whereas the unit ventilator fan must run at all times to heat the room. Partly to compensate the valve and trap manufacturer for the volume of business which this new scheme will take away from him he may be given the job of making the booster with an appropriation for each unit equivalent to the present price of

a good valve and trap. Less than half of the radiators will be equipped with boosters.

The Boiler Room: With the reduced load and decreased radiation instead of two boilers of 150 hp each, one always idle, there will be three identical boilers of 25 hp each, cross connected. Two of these will be used as hot water heaters, the third as a high pressure boiler supplying steam to the laundry and dishwashing, and acting as a reserve for the heating units. As high pressure steam is used not over 8 or 10 hours a day but one licensed engineer will be needed. The heating units will require cleaning rarely more than once a year. A boiler plant designed according to this principle has been in operation since 1913 and given almost perfect service. Hot water will be generated with full automatic oil or gas firing or by metered steam. The hot water boilers will be separately controlled, one supplying radiators in north rooms, the other those facing south. Thermostats controlling the temperature of the circulated water will be set at a point, depending on outside wind and weather, to produce the temperature desired on the floors. The Superintendent will have a new measure of control over his Engineering Department. By means of distance reading thermometers he can determine the temperature of any floor at any time, without leaving his office. Various automatic recording devices will chart wet and dry bulb temperatures, fuel consumption, etc., giving a continuous picture of what the power plant is delivering and what it is costing.

Hospitals are notoriously overheated. A large hospital recently visited was everywhere uncomfortably hot. One unoccupied private room was like an oven, and the nurse immediately opened both windows wide. Nurses automatically turn off the light, but never the heat, when a room is not in use. No thermometers were to be seen until the air-conditioned operating room was reached. Here were two thermostats labelled with surgeons' plaster "Keep at 75 deg." The thermometers stood at 84 deg. How much does it cost a day or a year to overheat a 1,000,000 cu ft of building by even 5 deg? This is a problem which the consulting engineer seems constantly to pass on to his hospital client.

It has been shown that a 150 hp boiler is operated at 100 lb pressure although only the laundry and dishwashing, 10 per cent of the total load, actually require high pressure and that for but 6 hours a day. The steam plant consumes fuel 24 hours a day the year round to maintain pressure and make up the constant loss by radiation through piping, regardless of whether steam is being used or not. Gas and electricity will be substituted for steam in kitchen equipment; and in sterilizers, which are only used intermittently, to eliminate expense when they are idle. Irrespective of the rate paid for current it is evident that this will effect major economies.

Such changes as the foregoing obviously involve many breaks with tradition but wherein is the scheme not sound?

The new plant will provide all of the essentials of conditioned air simply and economically. The same pumps, mains and radiators that distribute hot water to heat the building in winter will carry cold water or brine to cool it in summer. A drip pan under each radiator with drain connection will catch the condensation forming on the cold radiator in summer. Humidifying units in the corridors, controlled from the engine room, will circulate mist from the domestic hot water supply which will penetrate throughout the building. It is estimated that in the Middle Atlantic States the average winter temperature is 39 deg and the average outdoor humidity 75 per cent, and that for every 10,000 cu ft of air space in a home 5½ gal of water should be evaporated daily to keep the air healthy and comfortable. Thus the 400,000 cu ft which should be humidified in the hospital would require 220 gal a day. The booster unit in the patients' rooms will, when needed, supply air motion and fresh filtered air with windows closed and outside noises excluded.

How nearly will this adaptation of the heating system to air conditioning provide the results of a central plant? Cooling can be accurately controlled: dehumidification may at times be less than ideal, but humidification ample.

And what about operating cost, particularly in summer? In the New York District there are on the average some 5,000 hours in the year when heating is needed, and 500 when cooling is desirable, which with the insulated walls proposed will be considerably reduced. The Weather Bureau figures for the summer of 1932 show 485 hours with relative humidity between 75 and 85 per cent and 529 hours above 85 per cent—say 1000 hours when dehumidification is required. How many winter hours there are when artificially heated air is thirsting for moisture is not on the record.

At the request of the author an engineer associate made a computation of the comparative costs of supplying the same cooling by the two systems in the hypothetical 100 bed hospital. Assuming that 400,000 cu ft of air is to be cooled, the volume of brine circulated at 45 to 50 deg would be 40 gal per minute or 99 tons for a 10-hour period. This would require a 15 hp compressor motor. Using the fans and ducts with the same formulae as applied in the office building and allowing three air changes per hour for that portion of the total air recirculated would mean 17,600 cu ft per minute or 360 tons of air for a 10-hour period. Motors aggregating 70 hp would be required. To the lay mind these figures prove little but suggest much. It would appear that the hospital might content itself with the smaller tonnage.

It does not seem unreasonable to challenge the engineer to build around the principles suggested, a plant which will maintain the hospital's air conditions close to the borders of the comfort zone and give it something which, if not perfect, will be far superior to what it now has, at a cost within reach of an anaemic budget. The installation expense of the hot water cooling plant will be but a fraction of the fan and duct system. The central electrical or steam jet refrigeration unit would be considerably smaller for the former than the latter.

Many hospitals, in spite of the savings indicated in the new heating plant, will not be able to afford even the inexpensive type of air conditioning outlined. In these some form of portable equipment will be provided which can be wheeled into the room of the patient needing it as is now done with the portable x-ray and ultra violet lamp. Operating, delivery, constant temperature rooms and nurseries will have individual conditioning units, as well as a few rooms where patients suffering from conditions peculiarly susceptible to improvement under controlled temperature and humidity may be housed.

They are doing some things in Europe which, in principle, seem ideally adapted to hospital heating. These are being studied here but have not as yet been reduced to practical levels. As it is the aim to confine these speculations on the Hospital of Tomorrow to methods and principles which are now technically and economically available or may readily be made so, these prospective developments are merely noted, rather than incorporated in the specifications.

The Sulzer system developed in Switzerland and used extensively on the Continent and to some extent in England heats water by electricity through the night, utilizing cheap hydro-electric power or current supplied at production cost by Public Utilities, during off-peak hours. The hot water is stored in insulated containers of sufficient capacity to heat the building and supply domestic hot water for 24 hours, with ample reserve.

The purpose of a heating plant is to prevent the occupants of a building from losing body heat too rapidly for comfort. The three factors for health and comfort are air temperature, humidity and surface temperature. In England particularly the third factor is being emphasized by the use of wall panels and pipes instead of radiators. These warm the walls and ceilings themselves and reduce the emission of body heat which always radiates directly to cool surfaces. In the author's experience panel heat proved far more comfortable at 65 deg than our radiator heated rooms at 70 deg. The laboratories experimenting with electric panel heating have demonstrated that if the human body does not have to give up its heat to cold surroundings men can work in comfort in the lightest summer clothing in a room where the temperature is only 55 deg. The trend of this research and the imminence of its success is indicated by what L. W. Schad, research engineer, said last June, "At the present rate for electrical power direct heating by electricity is not economical. However, I look forward confidently to an economical system using pipes in the wall and ceiling which are heated in Winter and cooled in Summer by reversed and direct refrigeration respectively."

A few engineering details of some importance may be mentioned.

Ventilating: A limited amount of exhaust ventilation will be installed in corridors for general circulation and to remove excess heat and odors from the kitchen, laundry and various plumbing units. Portable electric air purifiers, not to be confused with ozonators, will be provided where needed. These devices cleanse and deodorize the air and strengthen its ion content. They are valuable adjuncts to air conditioning, particularly in the rooms of patients suffering from maladies which produce so much odor that no ordinary ventilation is adequate.

Piping: All piping used in the building will be of non-corrosive metal, with joints welded or sweated without the use of threaded fittings. This will largely eliminate water flow noises at elbows and joints as well as the danger of leaks. With no leaks to be feared branch control valves for both heating and plumbing pipes on the various floors may be eliminated, only riser valves being used, with a further saving by the omission of pipe shafts and access doors. Horizontal mains and connections will be run under the floor slabs, easily reached through removable panels of acoustical material which form the hung ceilings. Both hot and cold water pipes will be insulated with aluminum foil air cell covering.

Plumbing: Plumbing fixtures, particularly valves, faucets and fittings, will be of the best quality and design, their longer life and lower maintenance representing real economy, compared with the competitive articles so frequently installed in hospitals. For most purposes fixtures of standard type made by the thousand will replace the special hospital basins, bowls, sinks and controls, made a few at a time at a far greater cost. There will be fewer toilets and baths which the patients use but seldom and more conveniently placed automatic bedpan washers and other time-and labor-saving devices which the nurses use constantly. All plumbing will be made more quiet.

Electrical Work: The frequent troubles with electrical conduits, from abrasion and condensation of moisture around circuits and feeders, will be remedied by the omission of all conduits. "Park Cables" will be used for the feeders and circuits in the floors and walls. These require no protection other than the sheathing which is a part of the conductors. The cables are of the sort successfully adopted in underground work, with the difference that the feeders and circuits used in the buildings will be of the single conductor type with only one wire to a fixture. This wire is insulated, its protecting sheathing acting as the return wire for the grounded side. All electrical fuses will have been eliminated from light distributing switchboard and power panels. Combination thermal cutouts and noiseless toggle switches will be used on all small wiring, while the large feeders will be protected with the usual circuit breakers. The building will be lighted with ultra violet ray incandescent bulbs similar in appearance to the old electric light bulbs.

Sterilizing: Asceptic sterilization is perhaps the hospital's most technical and critical procedure. It consists of the application of moist heat at 212 degrees or more for a given period of time at a predetermined pressure, to destroy pathogenic bacteria and other contamination, in water, or on instruments, utensils, surgical dressings, rubber gloves, gowns, etc. Proper sterilizing means safety, faulty sterilization infection and perhaps death to the patient. The equipment and processes of sterilization are complex and the danger from mistakes, human and mechanical, causes constant concern to surgeons, nurses and management,

Sterilizing apparatus is made by firms specializing in hospital equipment on whose standards and recommendations as to sizes, types, methods of installation and operation the hospital and Consulting Engineer rely. Steam, electricity, gas and even kerosene are variously used. High pressure steam has generally been accepted as the most economical medium, a conclusion which probably would not be confirmed if all of the cost factors of installation, maintenance and operation could be arrived at accurately. Recently electrical equipment has been greatly improved and more generally used. But conforming to the essential principles of the steam apparatus it is overcomplicated, with many expensive and temperamental gadgets designed to control temperature and pressure, to protect the shell and heat units from damage due to burn-outs, and to record the time during which the articles being sterilized have been subjected to what temperature and what pressure.

Since our 100 bed hospital is to use electricity a comparison with steam is pertinent to the thesis:

There will be 25 sterilizing units, the factory cost of which will approximate $6,000 for steam and $8,000 for electricity. The installation of steam, providing 15 hp capacity in the boiler with an equal reserve, many hundred feet of steam mains and returns to sterilizers scattered all over the building, reducing valves, control valves, traps, gauges, etc., would be many times the cost of power wiring. The maintenance of the steam supply represents a constant expense, the electrical practically none at all.

The author is indebted to the Wilmot Castle Co. for the data in the following comparison of electric and steam consumption for one complete sterilization in each piece of necessary equipment. While these figures are approximate, most of them are based on actual tests and are sufficiently accurate for the purpose:

Table 3—Comparison of Electrical and Steam Requirements for Sterilizing

Apparatus	Size in Inches	No. of Units	Current Consumed per Sterilization		Steam Consumed per Sterilization	
			@ KW	Total KW	@ Pound	Total Pounds
Instrument Sterilizers	19x9x8	3	2	2	10	30
Instrument Sterilizers	20x12x10	3	3	9	10	30
Utensil Sterilizer	20x16x16	7	6	42	15	105
Bedpan Sterilizer	5 pan	6	6	36	15	90
Pasteurizer	36 bottle	1	...	3	...	10
Dressing Sterilizer	20x28	1	...	8	...	30
Dressing Sterilizer	20x36	1	...	9	...	34
Autoclave Lavatory	16x24	1	...	6	...	20
Water Sterilizers, pair	10 gal.	1	...	10	...	50
Water Sterilizers, pair	20 gal.	1	...	20	...	100
Total		25		149		499

Total cost @ 1c per kw hr, $1.49; @ 80c per thousand pound $.39.

Thus if the hospital had a low rate of 1c per kw for power, a not unreasonable assumption if much of the heavy sterilization of water and dressings can be done at night, at the off-peak rate; the total cost for one operation each of all units would be $1.49. Few hospitals have accurate figures on steam production. A 100 bed hospital might generate it at 80c per 1,000 lb, at which one sterilization would cost 39c or an apparent saving of $1.10 over electricity. However, the cost of keeping up 15 hp of high pressure steam throughout the 24 hours for an actual use of but five, plus the constant loss of steam by radiation, would undoubtedly wipe out this apparent saving several times over.

The hospital of tomorrow should be equipped with simpler and more economical sterilizing apparatus. The application of thermo-electric principles successfully used in other fields will provide simple and positive controls of steam pressure, temperature, and time; eliminate many of the present uncertainties and complicated operating procedures, and insure uniformly positive sterilization with far less delay than is now possible.

With the various changes outlined, the management, maintenance and operation of the mechanical and electrical plant will be so simplified that many of the old crew of engineers, electricians, and repair men may be removed from the payroll. The equipment will be inspected and serviced monthly by a Hospital Management Bureau at a small annual charge.

While the limitations of time and patience preclude any further prognostications, certain principles of approach may be suggested. The Building Committee, which in the past has accepted almost without question what the engineer has given it, will want to know more in advance. Questions will be asked,—is it needed, is it the best thing for the purpose, will it prove economical? In the investment field the old principle of *caveat emptor* has been superseded by the new dictum, *caveat vendor*. The burden of proof will rest with the consulting engineer, that his plant will accomplish what the hospital requires, will operate not at average, but maximum economy, be simple to keep in running order, and give every promise of long life. The consulting engineer will be a constant in the planning council and present with the architect and consultant at meetings of the Building Committee. Here he may sell quality and demonstrate the wisdom of paying 10 to 25 per cent more for the best, where the best is cheapest. Here he may render sound and constructive service by advising on the practical and economical approach to the mechanical innovations for which someone invariably calls in each hospital project.

The engineer will be expected to prepare a detailed forecast of mechanical operating cost for the hospital budget, and,—mark this,—under a retainer to supervise the operation of his plant for five years,—or even life,—making quarterly or semi-annual inspections and reports. How many times a fee of $250 or $500 could the consulting engineer save the hospital if he had the opportunity and authority to protect his plant from abuse and see that it was properly run!

In the hospital of tomorrow the consulting engineer will be an economist as well as a designer and by the application of sound and progressive principles will endow many beds.

Local Chapter Reports

Philadelphia

March 8, 1934. Following a delightful dinner, which was enjoyed by 72 members and guests of the Philadelphia Chapter in the dining room of the board of directors of the Philadelphia Savings Fund Society, Pres. W. P. Culbert opened the meeting.

The minutes of the previous meeting were approved and Treas. W. F. Smith read a report on the financial condition of the Chapter, which was ordered filed with the minutes.

C. V. Haynes, president of the A. S. H. V. E. and a member of the Philadelphia Chapter, gave a short address, during which he requested that a committee from the chapter be appointed to review Chapter 32 of The 1934 Guide, giving special attention to pipe sizes.

President Culbert appointed the following as members of this committee: W. F. Smith, E. N. Sanbern, and A. C. Caldwell.

J. D. Cassell, member of the Council, gave a short statement in connection with delinquent dues in the Society.

The meeting was then turned over to Mr. Smith, chairman of the Meetings Committee, who thanked Frank Cook for the unusual service rendered by him in seating 72 for dinner when only 50 had been provided for.

Mr. Smith called on A. E. Dambly, associate of H. B. Hackett, engineer for the mechanical equipment of the Philadelphia Savings Fund Society Building, who gave a short talk in connection with this work and then requested P. L. Davidson to give a more detailed description. Mr. Davidson used a chart showing the location of equipment and from which he gave a very clear explanation of the air conditioning system installed in this 33 story bank and office building.

Guides were then provided to show the members and their guests through the building. Secy. W. R. Eichberg reports that this inspection trip was of unusual interest as the building is air conditioned throughout and has proved very satisfactory during last summer and this winter.

Illinois

March 12, 1934. The regular meeting of the Illinois Chapter was held at the Hotel Sherman with an attendance of 119. This meeting was known as Presidents' Night. The guest of honor was C. V. Haynes, president of the A. S. H. V. E., who was accompanied on his visit to Chicago by A. V. Hutchinson, secretary.

Dinner was served at 6:30 p. m. in the Old Town Room and Pres. C. W. DeLand called the meeting to order in the Crystal Room at 7:30.

J. D. Small, W. B. Graves and E. M. Mittendorff were appointed to act as tellers of the election of the Nominating Committee.

The secretary, J. J. Hayes, read an invitation from the State Geological Survey to the Illinois Chapter to cooperate with a number of other engineering societies in the conference on Home Building in Illinois, at Urbana, March 15-17.

The election tellers reported the results of their count and the following 7 members received the largest number of votes and were accordingly declared elected: John Howatt, C. W. DeLand, J. J. Aeberly, R. E. Hattis, J. H. Milliken, J. J. Hayes and J. J. Haines.

A large placard on the wall of the meeting room tabulated the past presidents of the Illinois Chapter from the present back to the first president, who served during 1906-07. Many of these men were present and acknowledged personal greetings from the members.

A letter from Past President E. F. Capron was read, expressing his regret at not being able to be present due to his poor health. G. W. Hubbard was absent for the same reason. The Chapter requested that the secretary write Mr. Capron and Mr. Hubbard, wishing them a speedy return to good health. A moment of silent tribute was given for those past presidents who are now members of that eternal chapter.

John Howatt, 1st Vice-President of the A. S. H. V. E. and chairman of the Committee on Research, gave an excellent report covering the Society's activities in research.

President DeLand then introduced C. V. Haynes, president of the Society, giving a brief resumé of his many activities and his years of devoted service to A. S. H. V. E. affairs. President Haynes chose for the subject of his message to the Chapter, Your Society—What Does It Mean to You? He outlined the plans and prospects of the Society for 1934, stressed the need of the active support of every member, and mentioned the benefits each member receives from the Society.

President Haynes' talk was an inspiration to every member present.

The chairman of the Meetings Committee, S. I. Rottmayer, announced that he was going to build a $15,000 home and had decided to obtain the advice of four past presidents, J. F. Hale, H. M. Hart, E. V. Hill and S. R. Lewis, as to the best method of heating this new home. He specified that the system must be simple in construction and must heat comfortably with little expense and effort.

Mr. Hale urged the use of the vapor system to accomplish economical, automatic heating with extreme flexibility to accommodate sudden wide changes of outside temperature. He claimed for the vapor system rapid, uniform circulation, either under a slight pressure or a vacuum, with convectors or direct radiation.

Mr. Hart advocated the use of gravity hot water heat, having in mind the four essentials of a good heating system—comfort, economy, simplicity and low cost of upkeep. He claimed for hot water the maintenance of perfect heat balance at any desired temperature at any outside temperature, wind direction or velocity or position of the sun. He suggested the use of an oil burner with both outdoor and indoor thermostats, plus a master thermostat.

Dr. Hill favored the fan furnace type of system, which he said would deliver properly conditioned air just where it is needed, air which would be clean, humidified, perfectly controlled and distributed. He recommended the use of a noiseless two-speed fan with thermostatic control. The addition of suitable refrigeration would provide summer cooling.

Mr. Lewis described his choice as a modern heating system for the modern home. He would provide an oil burning hot water boiler with a noiseless circulating pump to provide positive circulation to convectors concealed behind grilles with individual valves in the basement. A damper with thermostatic control would be provided on the outlet of each grille. The living room only would be provided with an indirect heater in the basement with separate supply and return. In this heater, water could be circulated in the summer for cooling. Small copper piping would be used from boiler to convectors. A bathroom vent would be provided to an attic fan.

The discussion which followed these four talks was both interesting and lively. Secretary Hayes reports that Past Presidents' Night was without a doubt one of the most interesting meetings the Chapter has held for a long time.

St. Louis

March 5, 1934. In the absence of Pres. Paul Sodemann, the meeting, held at the David Ranken Jr. School of Mechanical Trades, was called to order by Vice-Pres. J. W. Cooper with 22 members and guests present.

The secretary, A. L. Walters, read a telegram from the Philadelphia Chapter extending an invitation to attend the Semi-Annual Meeting at Buck Hill Falls, Penn., June 20-22.

Secretary Walters reported for the treasurer a balance on hand of $386.03.

J. W. Cooper, chairman of the Program Committee, outlined the plans for the April meeting, when Mr. Hacker will speak on Heating and Ventilating in China.

The chairman of the Entertainment Committee, C. R. Davis, spoke of the proposed bridge party and it was moved by C. A. Pickett, seconded by L. W. Moon and carried that the Chapter hold a bridge party at the Kingsway Hotel at 50c per ticket.

D. J. Fagin, chairman of the Membership Committee, reported that the application of F. B. Fillo had been received.

The Chapter's Employment officer, E. A. White, said that the time seemed to be approaching when he should be relieved of his duties, as there seemed to be no further need for his services.

A rising vote of thanks was given to the David Ranken Jr. School of Mechanical Trades for the courtesies extended to the Chapter during the Air Conditioning Forum. Mr. Turner spoke for the school and expressed the opinion that it had profited as much as the Chapter.

G. B. Rodenheiser reported that E. P. Bradley and D. L. Moodie had served as speakers at meetings of the St. Louis Electrical Board of Trade.

Mr. Rodenheiser again expressed appreciation to the Chapter for its cooperation in the Open Forum on Air Conditioning and for its forum leaders and speakers for these meetings. The chairman replied for the Chapter and said that it was considered a privilege to be invited to act as sponsor and to furnish some of the speakers.

The last meeting of this forum was held in the school gymnasium following the Chapter meeting with the usual good and interested attendance. President Sodemann was the leader, his subject being Engineering of Air Conditioning.

The Inn at Buck Hill Falls

June Meeting in the Mountains

THE scene of the Semi-Annual Meeting 1934 will be high in the Pocono Mountains of Eastern Pennsylvania, a delightful vacationland, where mountains, valleys, waterfalls, small lakes and mountain streams abound. The Council has selected The Inn, at Buck Hill Falls, as meeting headquarters for a three-day meeting June 20 to 22 and the Philadelphia Chapter has assumed the responsibility of being host to the Society. The Inn is easily accessible from all points by railroad to Cresco, Pa., and by splendid motor roads, connecting with national highways. This playground in the Poconos is renowned for its scenic beauty and in June it will be at its best with laurel and rhododendron in full bloom.

The Entertainment Program is being planned by the Committee on Arrangements, composed of the Philadelphia Chapter members, Messrs. R. C. Bolsinger, W. P. Culbert, W. R. Eichberg, J. H. Hucker, W. F. Smith and M. F. Blankin. Entertainment has been planned for everyone and there will be a choice of golf, tennis, riding, fishing, lawn bowling, shuffle board, horseshoe pitching and swimming.

A tentative schedule of events provides the following: *June 19,* 7:00 p. m., Dinner and Meeting of the Council; *June 20,* 8:30 a. m., Registration, 9:30 Technical papers and reports, 1:30 p. m. Golf Tournament at Buck Hill Falls, 7:00 p. m. Steak Fry and Beer Party on Skytop Mountain with *A. S. R. E.* members; *June 21,* 9:30 a. m. Joint Technical Session with *A. S. R. E.* at The Inn, Buck Hill Falls, 1:30 p. m. Golf Tournament (A. S. H. V. E. Research Cup) at Buck Hill Falls course, 2:00 p. m. Ladies' Bridge Party, 7:30 p. m. Semi-Annual Banquet and Dance; *June 22,* 9:30 a. m. Technical papers and reports, 10:00 a. m. Motor Trip through Pocono Mountains for A. S. H. V. E. and *A. S. R. E.* ladies, 1:30 p. m. Golf Tournament, Kickers' Handicap at Skytop; 2:30 p. m. Ladies' Duplicate Bridge Party at Skytop.

Low American Plan Hotel Rates will be in effect and application has been granted for Reduced Railroad Fares under the Identification Certificate Plan at one and one-third fare for the round trip. Members will receive complete details about room rates, transportation cost, railroad schedules and motor routes through the mail, also further details of the entertainment and technical programs at May Chapter Meetings and in the June Journal. Blue arrows on road signs will point the way to Buck Hill Falls. Motorists should look for these markers.

Headquarters for the *American Society of Refrigerating Engineers* will be at Skytop and several joint social functions are being planned, as well as a joint technical session at which W. H. Carrier, Past President of both Societies, will preside. The regular sessions will be conducted by President C. V. Haynes of A. S. H. V. E. and Pres. A. R. Stevenson, Jr., of *A. S. R. E.*

The Philadelphia members want to make the Semi-Annual Meeting 1934 one that will go down in history as the most enjoyable summer meeting ever held by the Society and a cordial invitation is extended to every member to come to the Poconos, June 20 to 22, 1934.

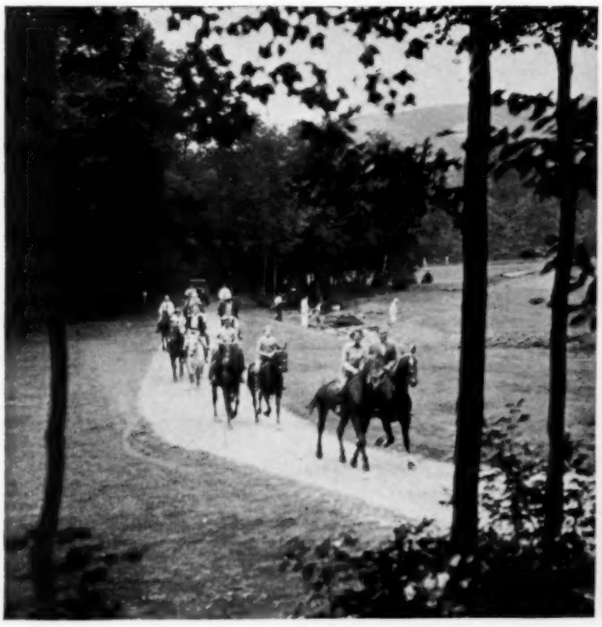
Teeing Off at Buck Hill

Fishing a Trout Stream

Shuffleboard

At the Golf Clubhouse

Along the Riding Trails



Bowling on the Green

PLAN TO BE AT BUCK HILL FALLS FOR THE SEMI-ANNUAL MEETING 1934

DEAN F. PAUL ANDERSON

Dean Anderson Taken By Death

F. PAUL ANDERSON, Dean of the University of Kentucky College of Engineering and President of the Society in 1927, died at his home, 1018 Richmond Road, Lexington, Ky., on April 8, at the age of 67, after several months illness. In the passing of Dean Anderson, engineering has lost one of its most colorful figures and he had a larger share than most men ever hope to have in bringing to pass the things he visioned would be. He saw the evolution of a small workshop into a College of Engineering and also the progress of science in adding in numerous ways to life's comfort and pleasure.

Affectionately known throughout the United States among engineers and former students of the University as "Little Paul" and "The Little Dean," his vision and outlook have been transmitted to a legion of "his boys" and to many national figures in engineering and industry.

Dean Anderson had a genius for companionship and friendship which evidenced itself in a generosity with his time, not measured by any possible return except from the pleasure of enriching lives of others with his own magnetic personality and inspiring them with his outlook, his knowledge and his ability to lay cares aside and to enjoy life. Human companionship was one of his hobbies, and the close friendships he made among leaders of engineering, first as a means of stimulating his own unique processes for training men, and second for the purpose of giving him many fields of industrial activity in which to direct the steps of his boys, who graduated from the College of Engineering, were developed largely in the weekly engineering assemblies which brought many notable scientists and scholars to Lexington. In this way the students in engineering became acquainted with the types and philosophies of outstanding figures in the engineering and business world. Dean Anderson had a definite philosophy with reference to the training of men, believing that men should be taught to work as the best means of bringing out their greatest talents and he believed that all steps in an engineering course should be taught from the standpoint of fundamentals, leaving the specialized training to the industries. He believed strongly that engineers should be broad in their tastes and sympathies and felt that these things could be accomplished by surrounding the student during his college days with examples of beauty expressed by the development of plant life, by animals and by minerals. The Annual Christmas Party, the Dahlia Garden, the rail from the first railroad laid in Kentucky, the library in the "old woodshop" at Dicker Hall were evidences of the Dean's manner of dramatizing the study of engineering. His was one of the first Colleges of Engineering to introduce electrical engineering as a major study and again was a leader in requiring cultural courses as a necessary part of engineering study. He was associated with many scientific developments, was an outstanding authority on motive power of railways, one of the first to experiment with the x-ray, and made many research investigations in his long and useful career which covered a period of 43 years at the University of Kentucky.

Dean Anderson was born at South Bend, Ind., February 10, 1867, and was graduated from Purdue University in 1890 with a Bachelor of Engineering degree. For a year he was an instructor in steam engineering at his alma mater from which he received his masters degree in 1894. In 1891, Dean Anderson joined the staff of the University of Kentucky and in 1892 he became Professor of Mechanical Engineering and Dean of the School of Mechanical Engineering; serving continuously, and since 1917 as

Dean of the College of Engineering. He built up the Engineering College at the University of Kentucky so that it took its place with the leading technical schools in America. Dean Anderson's training was primarily to work for the Studebaker Bros. Manufacturing Co., South Bend, where his father had been superintendent for more than a quarter of a century. His excursion into the teaching profession was intended to be of only a year's duration before he settled down in the manufacturing field. He became so fascinated with the training of engineers that he decided to make teaching his life work.

For 25 years Dean Anderson was engineer of tests for the Southern Railway Company and during that time developed many processes to improve railroad operation.

In 1921 Dean Anderson was appointed Director of the Research Laboratory of the A. S. H. V. E., located in the Bureau of Mines, Pittsburgh, Pa., and served in this capacity until August, 1925 directing the work from his office at the University of Kentucky and making monthly trips to Pittsburgh. During the years he was Director of the Laboratory, many scientific papers were prepared under his direction and among the most important work carried on was the development of the comfort zone. This work has received world-wide recognition and at the time of his death, Dean Anderson was interested in the building and operation of a laboratory at the University of Kentucky to study the effect of sunlight on plants and animals, this laboratory being made possible through the gifts of Percy H. Johnson, president of the Chemical Bank & Trust Company of New York.

At the 36th Annual Meeting of the Society held in Philadelphia, January 1930, announcement was made of an endowment created by Thornton Lewis, then president of the Society, for the F. Paul Anderson Medal, named in honor of the Dean, to be awarded to a member of the Society whose work or services in the field of heating, ventilating or air conditioning were outstanding.

The first award of this gold medal was made to W. H. Carrier in 1932.

In 1927, Dean Anderson was elected President of the American Society of Heating and Ventilating Engineers and he served on the Council from 1924 to 1928, as first vice-president in 1926 and second vice-president in 1925. He became a member of the Society in 1921 and served on a number of technical and Council committees which included the Executive Committee, Publication Committee, and the Special Committees responsible for the development of the Code of Minimum Requirements for the Heating and Ventilation of Buildings, Code for Testing Disc and Propeller Fans, Centrifugal Fans and Blowers, the Boiler Testing Code and the Code of Ventilation Standards, and at the time of his death was a member of the Advisory Council and the Committee on Ventilation Standards.

Dean Anderson held membership in and served on several committees of *A. S. M. E.*, was a member of the *National Research Council* (engineering division), the *Society for the Promotion of Engineering Education*, the *American Association for the Advancement of Science, Royal Society for the Encouragement of Arts, Manufactures, and Commerce*, the *Engineers Club of Cincinnati*, and the following fraternities and clubs: Tau Beta Pi, Sigma Chi, Triangle and the Lexington, Union, Ashland and Commercial.

Dean Anderson is survived by his widow, Mrs. Josephine Fisher Anderson, an only daughter, Mrs. R. W. Bozeman of Cleveland, his son, F. Paul Anderson, Jr. of Millburn, N. J. and two grandchildren.

On the day of the funeral the body of the Dean lay in state in Memorial Hall on the university campus, attended by a guard of honor composed of seniors from the College of Commerce, who were members of R. O. T. C.

Funeral services were conducted at 3 p. m. by Bishop H. P. Almon Abbott of the Episcopal Church and burial was in Lexington Cemetery.

Two of the Society's Past-Presidents, William H. Driscoll, New York, and Thornton Lewis, Newark, N. J., officially represented the Society at the services.

The grief of the Officers and the Council was expressed by President C. V. Haynes of the Society and a message of sympathy was sent to the family of Dean Anderson. W. T. Jones, Chairman of the Advisory Council, expressed the sorrow of this intimate group of the Society Past-President's who will greatly miss the Dean's cheery presence at their annual gatherings.

The Dean is dead but his spirit lives and "to his legion of friends throughout the world he has given the inspiration of his life and thought that they may reveal to a world whose fears are many that engineering, as the right arm of science, shall be used not for destruction but to add to human happiness," says the *Lexington Herald* in an editorial, "He Gave Engineering a Soul."

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the Journal of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Membership Committee as soon as possible.

When the Membership Committee has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 18 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some members by May 15, 1934, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
Adams, Eugene I., Chief Engr., Mich. State College, Lansing, Mich.	H. F. Reid J. H. Van Alsburg	L. G. Miller P. O. Wierenga

CANDIDATES

BENOIST, LEROY L., Mgr. and Htg. Engr., Benoist Bros., Mt. Vernon, Ill.

ELLIOTT, N. B., Br. Mgr., American Blower Corp., Milwaukee, Wis.

FERGUSON, R. R., Mgr. Trade Dept., American Blower Corp., New York, N. Y. (*Reinstatement and Advancement*).

GAY, L. M., Power Engr., Texas Power & Light Co., Dallas, Tex.

HEBLEY, HENRY F. J., Research Engr. and Member of Firm, Allen & Garcia Co., Cons. Engrs., Chicago, Ill.

KAMPISH, NICK S., Student, Pratt Institute, Brooklyn, N. Y.

MAILLARD, ALBERT L., Head of Air Cond. Div., Kansas City Power & Light Co., Kansas City, Mo.

MATTHEWS, J. E., Dist. Mgr., B. F. Sturtevant Co., Kansas City, Mo.

MERRILL, FRANK A., Htg. & Vtg. Engr., Office of Hollis French, Cons. Engrs., Boston, Mass.

MORRIS, ARNOLD M., Industrial Dept., U. S. Navy Yard, Philadelphia, Pa.

POTVIN, LEO J., Dist. Office Mgr., Hoffman Specialty Co., Inc., Chicago, Ill.

PRIESTER, GAYLE B., Student, Harvard Graduate School, Boston, Mass.

SHENK, D. H., Assoc. Prof. of Mech. Engrg., Clemson Agricultural College, Clemson College, S. C.

THOMAS, L. G. Lee, Vice-Pres., Economy Pumping Machinery Co., Chicago, Ill.

TOBIN, JOHN F., Sales Engr., American Blower Corp., Chicago, Ill.

WALKER, EDMUND R., Htg. Div., Fedders Mfg. Co., Inc., Buffalo, N. Y.

WASHINGTON, GEORGE, Sales Engr., Hoffman Specialty Co., Inc., Chicago Ill.

REFERENCES

Proposers	*Seconders*
D. L. Moodie	A. L. Walters
R. M. Rosebrough	D. J. Fagin
H. M. Miller	J. H. Volk
J. H. O'Brien	J. S. Jung
E. A. Bennett	D. L. Taze
Arthur Ritter	F. R. Still
W. H. Moler	T. D. Thomas (*Non-Member*)
J. F. Moss (*A. S. R. E.*)	J. W. Stockham (*A. S. R. E.*).
J. H. O'Brien	John Howatt
J. E. McClellan	L. L. Narowetz, Jr.
R. B. Dale (*A. S. M. E.*)	R. C. Knowles (*Non-Member*)
J. W. Hunter (*Non-Member*)	K. E. Quier (*A. S. M. E.*)
N. W. Downes	L. A. Stephenson
David Caleb	C. A. Flarsheim
N. W. Downes	L. R. Chase
W. E. Gillham	J. H. Kitchen
P. A. L. Foulds	H. B. Wiegner
W. T. Jones	E. A. Dusossoit
Edward Engel	F. D. Mensing
E. N. Sanbern	W. A. Bornemann
C. V. Haynes	Potter Bowles
F. H. Gaylord	M. C. Gillett
C. P. Yaglou	Theodore Hatch (*Non-Member*)
Philip Drinker	W. F. Wells (*Non-Member*)
F. T. Tingley (*A. I. E. E.*)	B. E. Fernow (*A. S. M. E.*)
C. H. B. Hotchkiss	S. B. Earle (*A. S. M. E.*)
C. V. Haynes	W. K. Simpson
N. P. Fenner	C. W. Stewart
J. E. McClellan	John Howatt
J. H. O'Brien	L. L. Narowetz, Jr.
V. P. John	W. F. Johnson
B. C. Candee	G. F. Erdle
C. V. Haynes	Potter Bowles
F. H. Gaylord	M. C. Gillett

Candidates Elected

In past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Membership Committee and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. II, Sec. VIII, of the By-Laws, the following list of candidates elected:

MEMBERS

BURCH, LAURENCE A., Mfrs. Repr., Milwaukee, Wis.

COCHRAN, L. H., Dist. Mgr., American Blower Corp., San Francisco, Calif.

FOGARTY, ORVILLE A., Mgr. & Chief Engr., Oil Burner Div., Canadian Fairbanks-Morse Co., Montreal, Que.

GLASS, WILLIAM, Mgr., Partridge-Halliday, Ltd., Winnipeg, Canada.

HUTCHINS, WILLIAM H., Chief Engr., Delco Appliance Div., General Motors Corp., Rochester, N. Y.

LANE, D. DUFFY, Supervisor, N. Y. State Insurance Dept., New York, N. Y.

MAGIRL, WILLIS J., Chief Engr., P. H. MaGirl Foundry & Furnace Works, Bloomington, Ill. (*Advancement*)

SEEBER, R. R., Head, Mech. Engrg. Dept., Michigan College of Mining & Technology, Houghton, Mich.

STEINMETZ, C. W. ARTHUR, Br. Mgr., American Blower Corp., Newark, N. J.

STREVELL, ROGER P., Co-Partner, Wm. R. Hogg Co., Asbury Park, N. J.

STUBBS, W. C., Design Draftsman, U. S. Govt., Norfolk Navy Yard, Portsmouth, Va.

TRUMP, CHARLES C., Pres., James Spear Stove & Htg. Co., Philadelphia, Pa.

WAGNER, FREDERICK H., JR., Mgr., N. Y. Air Cond. Dept., American Blower Corp., New York, N. Y.

WHITE, E. B., Cons. Engr. & Archt., Y. M. C. A., Chicago, Ill.

ASSOCIATES

EATON, WILLIAM G. M., Sales Engr., Pease Foundry Co., Ltd., Toronto, Canada.

FILLO, FRANK B., Mgr., Minneapolis-Honeywell Reg. Co., St. Louis, Mo.

HAMLIN, CHAUNCEY J., JR., Proprietor, Hamlin Air Conditioning Co., Buffalo, N. Y.

HEBERLING, C W., Htg. and Plbg. Contractor, Wayzata, Minn.

MCKINNEY, WILLIAM J., Dist. Mgr., American Blower Corp., Atlanta, Ga.

OLSON, BERNHARD, Secy.-Treas., Bryant Gas Heating, Inc., Chicago, Ill. (*Reinstatement.*)

ROLLAND, S. L., Design Engr., Oklahoma Gas & Electric Co., Oklahoma City, Okla.

SUPPLE, GRAEME B., Br. Mgr., American Blower Corp., Indianapolis, Ind.

TORNQUIST, EARL L., Supervisor, Distribution Operation, Public Service Co. of Northern Illinois, Chicago, Ill.

WASHBURN, M. J., Insulating Engr., Eagle-Picher Lead Co., Cincinnati, Ohio.

JUNIORS

STINARD, RUTHERFORD L., Htg. Engr., American Radiator Co., New York, N. Y.

WILLIAMS, FRANK H., Air Cond. Tester, Frigidaire Corp., Dayton, Ohio.